25X1

Page Denied

# TELEGRAPH AND TELEPHONE LINEMAN

Nadsmotrshchik Mezhdunogorodnykh Telegrafno-Telefonnykh Liniy Svyazi
[Telegraph and Telephone Lineman],
1955, Moscow, Pages 61-255

A. N. Gumelya,
Ye. V. Kirillov,
N. V. Luskinovich

## SECTION II. INTERCITY COMMUNICATIONS

## CHAPTER 8. PRINCIPLES OF TELEPHONE TRANSMISSION

### 8.1. The Concept of Sound

Telephony is the transmission of the sounds of human speech along wires by means of electric current.

Sound occurs as the result of vibration of any body. For example, a bell rings when its cap vibrates, a guitar sounds when its strings vibrate. The sounding body causes vibration of the particles of the surrounding medium. This may be observed in the following example. If a sounding bell is placed under a glass hood (as shown in Figure 8.1), the sound will be well heard, as also without the hood. But if the air is evacuated through an exhaust tube under the hood, the sound will not be heard even though the hammer be clearly seen to strike the cap. This experiment shows that the presence of a resilient medium (e. g., air, water, metal) is necessary for the propagation of sound.

Vibrations of the particles of a resilient medium are known as sound waves. Sound waves propagate in all directions from the source of sound. In the air sound is propagated with a velocity of approximately 330 m/sec. Moreover, the distance over which the vibrating particle of air departs from its mean position decreases as the distance from the vibrating body increases (that is, the vibrations progressively weaken).

If the sound waves encounter a body capable of vibrating in their path, they set it in vibration. Sound waves striking the ear of a person cause its tympanum to vibrate. The vibrations of the tympanum are transmitted through special bones of the ear to the aural nerves and excite them. These nerve excitations are transmitted to the brain and perceived as sound sensations.

The human ear is usually incapable of perceiving all sound vibrations, but it perceives those having a frequency of not less than 16 cycles and not more than 16 kilocycles. Even within these limits (range) the ear hears sounds differently. The ear is especially sensitive to sound vibrations with a frequency of approximately 1,000 cycles.

The principal values characterizing a sound wave, besides the velocity of its propagation, are the amplitude and frequency of vibration.

Most of the sounds encountered have a complex character, that is, they are formed by the simultaneous action of several sound vibrations with different frequencies and amplitudes.

The frequency of a sound vibration depends on the number of oscillations per second. The frequency of vibration determines the pitch of a given sound. The greater the frequency of vibration of a sounding body, the higher the pitch of the sound. According to the height of the pitch we distinguish the female voice from the male voice, the bass from the tenor.

Figure 8.2 shows that the complex sound corresponding to the letter a and produced by a male voice consists of several simple sounds which are represented graphically in the form of

the simplest oscillations (sine waves) 1, 2, 3, 4, etc. In all complex sounds one tone predominates. In Figure 8.2 the fundamental is represented by curve 1 and the other tones only give it the color which is referred to as the timbre of the sound.

The same complex sound produced on different instruments is easily distinguished due to the peculiar timbre of each instrument.

8.2 Principle of Speech Transmission Along Wires

The simplest method of achieving the transmission of speech along wires is shown in Figure 8.3. At station A, under the influence of sound waves, the metal diaphragm of a telephone with a permanent magnet vibrates in accordance with the vibrations of the sound waves (with the same amplitude and frequency). Vibration of the diaphragm causes changes in the number of magnetic lines of force of the permanent magnet. This causes changes in the induced emf in the coil of the telephone and creates an alternating current in the telephone circuit; the changes in the alternating current are proportional to the changes in the sound waves.

At station B, with a change of current in the coil of the telephone, the magnetic field of the permanent magnet of the telephone increases or decreases. The metal diaphragm vibrates according to these changes. Under the influence of the vibrations of the diaphragm the particles of air are set in vibration (that is, sound waves are formed which will be heard by the human ear).

The electric energy developed by the vibrations of the telephone diaphragm in such a simple telephone circuit is very small, hence telephone communication may be achieved in this

manner over small distances only. The electric energy in the circuit may be increased if, instead of the telephone at station A, a special telephone device known as a transmitter is used. The transmitter operates in the following manner. In the quiet state battery E (Figure 8.4) creates a direct current in the local circuit consisting of the primary winding of the transformer Tr, the capsule with carbon granules, and the diaphragm.

The vibrations of air particles arising during speech act on the diaphragm of the telephone transmitter and cause it to vibrate. This causes changes in the pressure of the diaphragm on the carbon granules, resulting in changes in the density of the granules and, consequently, in the resistance of the granules. The result is that the current flowing in the transmitter circuit does not remain constant, but pulsates according to the speech frequency. In the secondary winding of transformer Tr an emf is induced which causes an alternating current in the line and the coil windings of the telephone receiver at station B, the action of which current at the receiver does not differ from that already described.

Two-way telephone communications may be achieved by the arrangement shown in Figure 8.5.

In the transmission of speech by telephone the basic property determining the quality of transmission is the clarity of speech. Human speech contains vibrations of various frequencies from 20 cycles to 12 kilocycles. It has been established that speech is well understood if the frequency range from 200 to 2,700 cycles is transmitted.

## 8.3 The Telephone

A transmitter, serving for the conversion of speech vibrations into electrical oscillations, and a receiver, serving for the conversion of electrical oscillations into speech vibrations, are combined in a single instrument known as a telephone.

In order that the transmitter may operate, a source of current must be connected within its circuit (or, as is said, voltage supply must be fed to the transmitter). The transmitter is fed by one of two methods. In the first method the transmitter of each telephone is fed from its local (usually dry) battery, which is located at each telephone (Figure 8.5a). By means of telephone transformer $Tr_1$ the transmitter circuit $M_1$ is connected with line $L_1$-$L_2$ and telephone receiver $T_2$. The designation of such a supply system is abbreviated as an MB (local battery) system.

In the second method the telephone transmitters are fed from a common battery located at the central exchange. This system of supply, the circuit for which is shown in Figure 8.5b, is referred to as the TsB (central battery system). Transmitter $M_1$ and transmitter $M_2$ are fed from the common battery TsB across coils $RK_1$ and $RK_2$, containing a large number of turns of insulated wire wound on steel cores (chokes). The alternating speech current from the transmitting telephone proceeds to the receiving telephone without passing through the battery circuit, since the chokes offer considerable resistance.

Let us examine the construction of the most widely used transmitter (Figure 8.6). The transmitter consists of a brass housing 1 with an opening. At the base of the housing a carbon terminal 5 is held in place by means of screw 6 and nut 8. The



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

terminal is insulated from the housing by means of special washers 2, 3, 4, and 7. Carbon terminal 5 has six grooves into which fit brass spiders 9 and 10, serving to hold a felt washer (pad) 11 against the diaphragm 13. Grooves in the pad correspond to projections on the carbon terminal. When the pad is slipped over the terminal its edge extends above the upper surface of the terminal and forms six cells 12. By means of a special machine these cells are filled with equal amounts of carbon granules. Diaphragm 13 is a disc 0.5 mm thick and made of pressed carbon powder and coal tar. The diaphragm is covered with a thin sheet of mica 13 and held in the capsule by snap ring 14.

The transmitter capsule is placed in the telephone housing. Connection to the transmitter is made by means of two springs, one of which contacts screw 6 and the other contacts the capsule housing 1. The resistance of the carbon filling is not the same for all uses. For MB telephones low-impedance transmitters are used, having a resistance of 30 to 65 ohms. For telephones of the TsB and ATS [automatic telephone exchange] systems medium-impedance and high-impedance transmitters are used with respective resistances of 65-145 ohms and 145-300 ohms.

Figure 8.7 shows the construction of the most widely used type of telephone receiver. The plastic housing 1-2 contains a permanent magnet, consisting of three (or two) steel rings. The pole pieces 4 are fastened to one of the rings. Over the pole pieces are placed coils 5 with plastic forms and windings of copper wire with a resistance of 60 ohms each connected in series.

Steel diaphragm 7 is placed at the end piece of the housing, the necessary spacing between the pole pieces and the diaphragm

being provided by a fiber ring 6. Earpiece 8 is screwed onto the housing. The ends of the coil windings are brought out to terminals which are fastened by means of insulating bushings and washers to the magnet rings.

6.4 Telephones

Telephones are distinguished according to the method of feeding the transmitter, the design, and the ringing system.

According to the method of feeding the transmitter, telephones are classified as MB sets or TsB sets. Designwise, telephones are classified as portable or stationary. The stationary phones are wall phones or desk phones. According to the ringing system, telephones are divided into magneto phones or buzzer phones.

The MB telephone is used for service of subscribers connected to MB exchanges. The basic diagram of the MB phone is shown in Figure 6.8.

When the equipment is not in use the telephone hangs from lever RP. In this case the supply circuit of transmitter M is disconnected from battery B by springs 4-5, and the receiver T and transformer Tr are disconnected by springs 1-3; the bell Z is connected to line $L_1$-$L_2$.

With the arrival of a ring from the line, the ringing current (bypassing the coil of magneto Ind through shunt Sh) passes through the bell. Upon the transmission of the ring, the magneto current flows to the line; at the same time the bell is shunted by springs 6-7 of the shunt Sh, since the drive shaft of the magneto (in its rotation) moves in the clockwise direction, and the ringing current does not pass to the telephone.

Upon lifting the telephone, lever RP closes contact springs 1-2 and 4-5, with the result that a call circuit is formed for the reception and transmission of speech.

During conversation the pulsating current in the circuit of transmitter M is converted by transformer Tr to an alternating current, which is applied to line $L_1$-$L_2$ across contacts 1-2 and magneto shunt Sh.

The speech current coming from the line and across magneto shunt Sh is applied to the receiver T.

The TsB telephone is used for service of subscribers connected to TsB exchanges. Figure 8.9 shows the basic diagram of a TsB phone connected to a manual telephone exchange.

When the telephone is hanging from lever RP the phone bell Z is connected to line $L_1$-$L_2$. Since in the TsB system the common battery of the exchange is connected to the line, in order for the battery current not to flow through the bell a capacitor K with a capacitance of 1 microfarad is connected before the bell.

In order to ring the station the subscriber lifts the telephone from lever RP, contact springs 1-2 close, and the supply current from the exchange battery flows through transmitter M and through the parallel balancing resistance R = 300 ohms. Thereupon the ringing equipment at the exchange goes into operation and the telephone operator may connect the calling subscriber with the requested phone. The incoming magneto ringing current (from the exchange) flows through capacitor K and the bell Z. Thereupon the bell rings.

The speech current created in the transmitter flows through two circuits: part of it flows through winding I of transformer Tr to the line and to the telephone, the other part flows through winding II of the transformer and through resistance R.

The turns and resistances of the windings are so chosen that the magnetic fluxes of windings I and II are approximately equal in value and opposite in direction, hence they have practically no effect on winding III and stray speech current does not reach receiver T of the speaking subscriber.

In reception, the incoming speech current from the line passes through the circuit: conductor $L_1$, springs 1-2 of lever PR, winding I of transformer Tr, and then through transmitter M and partially through winding II of transformer Tr and resistor R to conductor $L_2$.

Windings I and II of transformer Tr are connected so that the incoming speech current from the line creates in them additive magnetic fluxes. These fluxes induce in winding III a current which flows through the receiver T.

For telephone communications under field conditions use is made of portable MB phones with magneto or buzzer ringing which are known as unified phones. The telephone is placed in a wooden or plastic box equipped with a strap for carrying it over the shoulder.

Figure 8.10 shows the basic diagram of the UNAI-42 telephone and Figure 8.11 the basic diagram of the TAI-43 telephone. Essentially the components of these phones are the same as in the MB wall phone,

but the lever switch is replaced by switch K in the handle of the telephone. The telephones have a special button ShK, the function of which is explained below, and two dischargers Rz for protection of the phones against lightning currents.

We shall now examine the operation of the UNAI-42 telephone. The exchange is called by magneto Ind. Upon turning the magneto crank, spring switch 1-2-3 closes contact springs 2-3 and current flows along the circuit: left end of winding Ind, contact springs 2-3 of the magneto switch, button ShK, conductor $L_1$, the other telephone or switchboard, conductor $L_2$, right end of winding of Ind.

The magneto current does not flow in the right-hand portion of the circuit, since it is shunted by contact springs 2-3 of the magneto switch. If upon the arrival of a ring button ShK is depressed, the shunt circuit is broken and the ringing current flows along the circuit: the left-hand contact of winding Ind, bell Z, conductor $L_1$, etc, and the bell rings. If upon turning the magneto crank and depressing button ShK the bell does not ring, there is a break in the line or the ringing circuit is inoperative.

Ringing from the line or from an exchange for UNAI-42 equipment is performed by the transmission of a magneto ring, wherein the current follows the following path: from line $L_1$, through bell Z and contacts 1-2 of magneto Ind (closed when the magneto is idle), to line $L_2$ and to the magneto of the calling phone or exchange.

In order to carry on conversation the supply circuit of the transmitter is closed by pressing switch K in the handle.

The pulsating current of the transmitter circuit is converted by the transformer into alternating current, which reaches the line and the exchange or another telephone along the following circuit: terminal 4 of transformer Tr, magneto contacts 1-2, line $L_2$, another telephone or a switchboard, line $L_1$, capacitor $K_1$, common point 2, transformer winding I, capacitor $K_2$, resistor IV, and transformer winding III. The speech current does not yet reach the receiver.

The speech current flowing from the line passes along the following circuit: line $L_1$, capacitor $K_1$, branches out through the transmitter and transformer winding I, through the receiver T, point 5 and transformer winding II, magneto contact 1-2, line $L_2$. The current flow in the TAI-43 telephone follows a similar scheme.

For rapid detection of faults in the telephones it is necessary to know the symptoms of the faults peculiar to each type.

Table 8.1 lists the symptoms of the more characteristic faults in the UNAI and TAI-43 telephones.

TABLE 8.1

FAULTS IN UNAI AND TAI-43 TELEPHONES AND METHODS OF ELIMINATING THEM

| Symptom | Possible fault | How to locate and eliminate fault |
|---|---|---|
| 1. With load across $L_1$ and $L_2$ terminals magneto handle is turned without effort; upon pressing shunting button bell does not operate. | Magneto does not generate current; spring 2-3 of magneto shunt are not contacting, terminal springs do not connect with contact pins of armature semiaxis. | Remove phone from box, examine and check operating condition of magneto shunt and reliability of connection between the axle pins and contact springs; adjustment is made so that in the idle state springs 1 and 2 make contact and 2 and 3 are open and, conversely, during magneto operation |

| | | |
|---|---|---|
| | | springs 2 and 1 are open and 2 and 3 make contact. Unfasten the screws holding the terminal contact spring (to the right) or the magneto shunt (to the left); carefully withdraw the shunt or the terminal spring a little way; correct the springs so that they exert pressure against the pins of the armature semiaxis; put the terminal contact spring or shunt in place. |
| 2. With load across $L_1$ and $L_2$ terminals magneto handle is turned with effort; upon pressing ShK bell does not operate. | A defect in the bell or, upon pressing ShK, spring 2 does not withdraw from spring 1. | Check operation of springs upon pressing ShK; loosen both nuts of the armature set screw; moving the armature up or down, adjust for proper spacing between the sides of the armature and the cores, fasten the nuts of the set screw. The gap between one side of the armature and a core, with the other side touching the core, must be 0.15-0.2 mm. The hammer must not be in contact with the rim of the bell cap. |
| 3. With no load across $L_1$ and $L_2$ terminals magneto handle is turned with effort; upon pressing ShK bell operates. | Discharger breakdown, $L_1$ and $L_2$ terminals shorted across discharge plates. | Disassemble discharger, inspect inner surface of discs. If beads were formed by discharger breakdown, carefully remove them with a file, knife, or screwdriver without scoring the plates. Wipe the plates and mica spacers. Reassemble the discharger. |

| | | |
|---|---|---|
| 4. Blowing upon the transmitter, no sound is heard in receiver (with speech button depressed). | No contact between speech-button springs; no contact between springs of transmitter cap and capsule; poor plug contact; a short or break in the strands of the telephone cord; defective transmitter capsule or receiver. | Examine and check operating condition of mentioned parts. If granules are moist, dry capsule by application of heat, but do not hold it close to flame. If granules have become fused and there is no reserve supply, the fused lumps must be carefully ground and the granules equally distributed among the cells of the felt pad. |
| 5. Blowing upon the transmitter, no sound is heard in receiver. | A phone element not making proper contact; element worn out; faulty transformer winding. | Check connection of element and its operability. |
| 6. Blowing sound heard in receiver without depressing speech button. | Speech-button springs making contact. | Remove speech button to eliminate fault; for this purpose it is necessary to reset the displaced springs upward or downward, depending on the nature of the departure from the correct position. |

# CHAPTER 9. TELEGRAPH COMMUNICATIONS WITH MORSE APPARATUS

## 9.1. Characteristics of Telegraph Communications

In telegraph communications the transmitted message is obtained at the receiving station in tape-recorded form. This record is presented in the form of a document from which it is possible to ascertain the content of the message, the time of transmission and time of reception of the telegram, etc. In this respect telegraph communications have the advantage over telephone communications.

Telegraph communications are divided into trunk, intra-oblast, intra-rayon, and city communications.

Trunk telegraph communications link Moscow with the republic, kray, oblast, and certain other large centers, and also interconnect these centers.

Intra-oblast telegraph communications connect the oblast center with the rayon or inter-rayon stations and also provide communications between the rayon centers and adjacent oblasts.

Intra-rayon communications are conducted within the limits of the rayons.

Large cities have city telegraph communications which link the central telegraph station with the city telegraph branches.

A great variety of apparatus is used for telegraph communications. One of these records the telegraph transmission in code form on tape (e. g., Morse apparatus), and the others print letters and numerals (start-stop teletypewriters and Baudot apparatus).

The Morse apparatus is the simplest of the telegraph instruments presently in use. In comparison with the start-stop teletypewriters and Baudot apparatus it is relatively inefficient. However, it is simple and convenient, quite stable in operation, and relatively immune to line disturbances. Hence, the Morse apparatus is widely used for auxiliary communications in adjusting lines and investigating faults. For example, before putting Baudot telegraph apparatus in operation conversation is achieved by means of auxiliary Morse equipment.

## 9.2. Operating Principle of Telegraph Apparatus

The simplest telegraph communication between two stations with the use of electro-magnetic telegraph apparatus is shown in Figure 9.1.

At station A there is a transmitter (key), an electromagnet with a recording device, and a battery with one terminal grounded. This arrangement is repeated at station B. The stations are joined by an ungrounded conductor.

Telegraph transmission from station A is performed by depressing the key. Thereupon current flows from the positive terminal of the battery, through contact 2 of the key, and along the conductor to station B. The key at station B is open, hence the current flows through contact 3, the winding of electromagnet 1, and returns to the negative terminal of the battery at station A through ground.

The current flow magnetizes the core of the electromagnet at station B, the armature attracts and holds the end of a recording lever with an ink-moistened roller against a moving paper tape. This leaves a mark on the tape in the form of a line. The length of this line will depend on how long the key is depressed at station A. Long depression of the key causes the recording unit to mark the tape with a long line (a dash) and short depression causes a short line (a dot).

Various combinations of short and long signals (i. e., dots and dashes) form the Morse code given in Table 9.1. In this code, for each letter, digit, or symbol there is an assigned combination of dots and dashes.

In transmitting from station B the key located at that station is depressed, which causes the electromagnet at station A to close its contacts.

TABLE 9.1. THE MORSE CODE

| Item No | Letters | Characters |
|---|---|---|
| 1 | a | . - |
| 2 | b | - . . . |
| 3 | v | . - - |
| 4 | g | - - . |
| 5 | d | - . . |
| 6 | e | . |
| 7 | zh | . . . - |
| 8 | z | - - . . |
| 9 | i | . . |
| 10 | k | - . - |
| 11 | l | . - . . |
| 12 | m | - - |
| 13 | n | - . |
| 14 | o | - - - |
| 15 | p | . - - . |
| 16 | r | . - . |
| 17 | s | . . . |
| 18 | t | - |
| 19 | u | . . - |
| 20 | f | . . - . |
| 21 | kh | . . . . |
| 22 | ts | - . - . |
| 23 | ch | - - - . |

(Table 9.1 Continued)

| | | |
|---|---|---|
| 24 | sh | - - - - |
| 25 | shch | - - . - |
| 26 | ', " | - . . - |
| 27 | y | - . - - |
| 28 | yu | . . - - |
| 29 | ya | . - . - |
| 30 | y | . - - - |
| 31 | e | . . - . . |

| Item No | Digits and punctuation marks | Characters |
|---|---|---|
| 32 | 1 | . - - - - |
| 33 | 2 | . . - - - |
| 34 | 3 | . . . - - |
| 35 | 4 | . . . . - |
| 36 | 5 | . . . . . |
| 37 | 6 | - . . . . |
| 38 | 7 | - - . . . |
| 39 | 8 | - - - . . |
| 40 | 9 | - - - - . |
| 41 | 0 | - - - - - |
| 42 | period | . .  . .  . . |
| 43 | semicolon | - . - . - . |
| 44 | comma | . - . - . - |
| 45 | colon | - - - . . . |
| 46 | quotation mark | . - . . - . |
| 47 | question mark | . . - - . . |
| 48 | + (plus) | . - . - . |
| 49 | - (minus) | - . . . . - |
| 50 | equal sign | - . . . - |

(Table 9.1 Continued)

| | | |
|---|---|---|
| 51 | parenthesis | - . - - . |
| 52 | slant bar | - . . - . |
| 53 | hyphen | - . . . . - |
| 54 | number | - . . - . |
| 55 | received, understood | . . . - . |
| 56 | I begin transmission | - . . - - . |
| 57 | reception good | . - - .  - - - |
| 58 | wait | . - - . . . |
| 59 | not received, not understood | . . . . . . . . |

## 9.3 The Morse Apparatus

The Morse apparatus consists of a receiver with a recording unit, a clockwork mechanism for movement of the tape, a key (transmitter), and auxiliary devices. A general view of the Morse apparatus is given in Figure 9.2.

The receiver of the Morse apparatus consists of an electomagnet with an armature. The electromagnet (Figure 9.3) consists of two windings, each of which contains approximately 6,200 turns of silk-insulated copper wire with a diameter of 0.2 mm. The windings are fitted over cores 1 of soft, annealed steel fastened by a steel cleat 2. For protection against disturbance each winding is encased within a thin brass or hard-rubber jacket. Resistance of the two series-connected windings is 600 ohms.

The cores of the electromagnet are tubular. At the end of each core there is a pole piece 3 and 4. Armature 5 is tubular also.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

The recording unit (Figure 9.2) consists of a recording lever 5 turning on axis 6. The shaft of the recording roller 15 is located in a groove at the left end of the recording lever. The armature is at the right end of the lever. The right end of the lever is drawn upward by a helical spring 11, the tension of which is adjusted by means of nut 25 with pin 26. The swing of the recording lever is limited by two screws 18 and 20 on support column 19.

With the passage of current through the winding 21 of the electromagnet the armature is attracted to the pole piece 27, causing the right end 8 of the lever to be lowered and the left end to be raised. Thereupon the recording roller contacts the tape moving above it. With interruption of the current the right end of the recording lever is returned by the helical spring to its previous position and the recording roller drops, losing contact with the tape.

The lower portion of recording roller 15 is immersed in inkwell 12 so that upon rotation the entire surface of the roller is moistened with ink.

The electromagnet may be raised or lowered by means of screw 17, moving it toward or away from the armature. In this way the force of attraction of the armature to the cores of the electromagnet may be controlled.

The clockwork mechanism transports the tape at a uniform rate. It consists of a drum with a mainspring, a system of toothed drive gears, a governor (vane), and a braking unit.

The drum and mainspring are checked by a ratchet wheel 35 (Figure 9.4) at the rear wall of the drum. A pawl 2, under pressure of a spring 37, engages the teeth of the ratchet wheel and prevents counterclockwise movement of the drum.

Complete winding of the mainspring is achieved with seven revolutions of the drum. This provides uninterrupted operation of the mechanism for 20-23 minutes with the drum rotating at about 0.3 rpm. The mainspring is protected against overwinding by means of a star wheel 24 mounted on an axle screw 38 on the drump cap 22. The star wheel has eight teeth, seven of which are concave and the other is convex. At the end of the drum shaft a collar with a pin is held in place by a nut.

In winding the mainspring the concave surface of the star wheel slides over the fixed collar, turning in the clockwise direction over the pin. When the eighth, convex tooth of the star wheel encounters the pin further winding of the spring is not possible. During rotation of the clockwork mechanism the star wheel is turned in the counterclockwise direction by the rotating prong of the collar until the convex tooth no longer presses against the collar pin, with the result that the spring ceases to unwind.

A fourth axial shaft of the clockwork mechanism extends from the housing of the apparatus. To it is fastened a tape-transport roller 1 (Figure 9.2) with a grooved surface. Above the tape-transport roller the paper tape is held by a tape-tension roller 2. The tape is guided by a roller 4 consisting of a brass cylinder over which are fitted two short tubes with guiding edges between which the tape is drawn.

In order to insure uniform movement of the tape the clockwork mechanism is provided with a governor (vane) (Figure 9.5). Rotated movement of the vane shaft is imparted by the clockwork mechanism through a worm gear. In the idle state the blades of the vane are held in an almost vertical position by a helical spring 1 (Figure 9.5a). With rotation of the axis, under the influence of centrifugal force the blades of the vane tend to unfold, overcoming the tension of the helical spring (Figure 9.5b). The more rapid the rotation of the axis, the more the blades fan out and the greater the air resistance encountered by the blades. If the speed of the mechanism decreases due to some accidental cause, the tilt of the blades decreases and the air resistance against the blades decreases, with the result that the speed of the mechanism begins to increase. The clockwork mechanism will operate at a certain constant rate. The telegraph tape is usually drawn at a rate of approximately 160 cm per minute.

The clockwork mechanism is started and stopped by means of brake 9 (Figure 9.2), the handle of which extends from the front of the housing at the lower left corner.

<u>The Key (Transmitter)</u>. Figure 9.6 shows the key by means of which the Morse apparatus transmits telegraph signals. The key is a double-arm copper lever 4 with its axis located in a copper fulcrum 2. At the end of the longer arm of the lever there is a wooden knob 10. At each end of the key there is a contact screw 6 and 8. Brass inserts 3 on the wooden block 1 and beneath the contact screws have flat contact springs 7 with silver tips.

In the operating-current connection of the apparatus the right end of the lever is constantly drawn downward by helical spring 9, closing contacts 6 and 7. If the apparatus is connected for continuous-current operation, the left end of the lever is drawn downward by a helical spring, closing contacts 7 and 8. These schemes for connection of Morse apparatus are described below.

The swing of the Morse key is adjusted by means of contact screw 6.

Auxiliaries. In addition to the receiver and key, the Morse apparatus has a galvanoscope or milliammeter and a combined laminated lightning-arrester and switch.

The galvanoscope or milliammeter serve to indicate the presence of current in the circuit and to determine its approximate value and direction. The scale of the instrument has divisions to the right and left of the zero position (40-0-40) corresponding to current values of up to 40 ma in either direction.

The combined laminated lightning-arrester and switch (Figure 9.7) serves to protect the apparatus against damage due to lightning currents. At the same time it serves as a switch, for by inserting a plug into one of the outer jack positions A or B one or the other conductor may be grounded. By inserting the plug into the middle jack position B the line conductors are connected directly and the apparatus is excluded from the circuit.

## 9.4. Disassembly, Reassembly, and Adjustment of Morse Apparatus

Disassembly. For thorough cleaning it is necessary that the apparatus be completely disassembled, all the components washed in



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

kerosene, and cleansed. Before disassembling the apparatus it is necessary to have at hand a container with kerosene, rags, and screwdrivers of various sizes.

Disassembly of the apparatus proceeds in a definite sequence:

1. remove inkwell 12 (Figure 9.2) by unscrewing the screw fastener;
2. remove the container with the tape;
3. unwind the mainspring of the drum.

In order to shorten the time required to unwind the mainspring hold the drum handle with the left hand and with a thin screwdriver press down on the righthand portion of the ratchet-wheel pawl so that it does not fall between the teeth of the ratchet wheel. The drum may then be turned through half a revolution in the counterclockwise direction. As soon as pressure on the screwdriver is released the pawl again engages the teeth of the ratchet wheel and it will not be possible to turn the drum. Turning the drum handle to a convenient position, the screwdriver is again pressed against the pawl, freeing the drum for another half turn in the counterclockwise direction. This procedure is repeated until the convex tooth of star wheel 24 does not abut against the prong of the collar. For complete unwinding of the mainspring it is necessary to remove the star wheel, for this purpose the collar holding the drum is unfastened and turned onto the screw located on the drum handle. The screw serving as the axis of the star wheel is then unscrewed. The ratchet wheel is again freed from the pawl and the drum is turned to the left until the spring is fully unwound. The position in which the drum is easily removed from its shaft is then found and the drum is removed.

4. Disconnect the ends of the windings of electromagnet 21 from their terminals;
5. remove the wood screws holding the apparatus to the wooden plate;
6. remove the screws fastening the clockwork mechanism to the metal frame;
7. unscrew screws 31 and 32 and carefully remove the tape-transport bracket;
8. remove tape-tension lever 3 with tape-tension roller 2 and the supporting shaft;
9. remove recording roller 15 from its shaft by pressing it outwards with the fingers;
10. remove the lefthand and upper covers of the housing;
11. remove the pin fastening the two gears on the fourth axial shaft and then remove the shaft with the tape-transport roller;
12. unscrew screws 28 holding the backing block and remove it;
13. unscrew the four screws 7 fastening the righthand wall of the housing; the wall and the recording lever 5 may then be moved to the right and removed;
14. remove the plate under adjusting nut 17 of the electromagnet; unscrew the two screws of the upper righthand brace and lift the electromagnet out;
15. remove the governor by unscrewing the two screws fastening the governor frame on the rear wall of the apparatus;
16. place the rear wall of the housing on the table, unscrew screws 7 at the corners of the forward wall, then carefully remove the latter;
17. remove the shafts of the clockwork mechanism from their seats.

Wash the parts in kerosene, clean and dry them.

Grease the seats and tips of the shafts.

Reassembly of the apparatus is performed in the reverse order.

Adjustment of the Morse apparatus is both electrical and mechanical.

Mechanical adjustment of the receiver consists in correcting the placement of the electromagnets and the recording roller, correcting the swing of the recording lever, and correcting the tension of the armature's helical spring.

Turning nut 17, raise the electromagnet to the upper position until it is one turn away from being unseated. Then set lower screw 18 of the support column so that upon depressing the armature by hand the gap between armature and pole piece 27 of electromagnet 21 is 0.2-0.3 mm (twice the thickness of the telegraph tape). After this, upper screw 20 of support column 19 is set so that the swing of the recording lever is 1 mm. In addition, check to see that the recording roller permits free passage of the tape. Starting the clockwork mechanism and lightly depressing the armature by hand, the roller must ink the tape with a solid line without impeding movement of the tape. If it is noted that the tape is hindered by strong pressure of the recording roller or, on the other hand, that the ink line is completely absent or broken, change the position of the cover plate at the left end of the recording lever.

Electrical adjustment of the receiver is performed to insure that the short signals (dots) transmitted by the key pass through the electromagnet. If the dots run together on the tape, then the helical spring must be tightened. If this does not help, lower the electromagnet. If the dots disappear, reduce the tension on the helical spring.

The normal operating current for the Morse apparatus is 15-20 ma.

9.5. Faults in Morse Apparatus and Their Causes

Breaks in the Circuit. These may be caused by: a break in a line conductor, fouling of the key contacts, faulty grounding, a break in a wire within the apparatus or in the windings of the electromagnet.

In order to determine the cause as well as the location of the fault a step-by-step test is performed. If, for example, it is apparent that the apparatus itself is operative, then the cause is a break in a conductor. If it becomes apparent that the cause of the break lies in the apparatus, then, by successive replacement of the individual parts of the apparatus, locate the fault and eliminate it.

Unintelligible Reception, Jumbled or Broken Characters. The cause may be poor adjustment of the recording system or strong current leakage in the line.

Unintelligible Operation of the Morse Apparatus, Appearance of Extraneous Signals. This may be due to contact between line conductors or faulty station wiring.

Clockwork Mechanism Stopped. This may be caused by: a broken mainspring; extreme weakening of the helical spring of the governor; fouling of the clockwork mechanism; loosening of the brake lever and uncontrolled braking of the mechanism; extreme pressure of the recording roller against the tape; tape incorrectly threaded.

Tape Does Not Feed. This may be caused by: tape fouled in reel; tape locked in roller rims; tape-transport roller not gripping tape, grooved surface of roller worn or dirty.

## 9.6. Schemes for Connection of Morse Apparatus

There are two basic schemes for connection of Morse apparatus; the continuous-current connection and the operating-current connection, permitting the connection of several intermediate stations between two terminal stations. Figure 9.8 shows the arrangement for continuous-current connection of two terminal stations and one intermediate station. It is characterized by the fact that current flows in the circuit at all times and the armatures of all apparatus are attracted to the armature pole pieces at all times. The line battery may be located at one station or divided among the stations so that the voltages of all these batteries are additive.

In operating a key the signals are received at the receivers of all the connected Morse apparatus, including the receiver of the transmitting station.

In the laminated discharger at each terminal station a plug is inserted into one of the outer jack positions not connected to a conductor. At the intermediate station the plug is not inserted into the laminated discharger.

Figure 9.9 shows the arrangement for operating-current connection of two terminal stations and one intermediate station. In this arrangement each station must have its own battery, which is connected to the line only upon pressing the key. Unless the system is in operation there is no current in the line. During keying at any station the receivers of all other stations on the line will operate. The receiver of the transmitting station will not operate (that is, the transmission is not monitored). The plug of the laminated discharger is installed in the manner described above for the continuous-current arrangement.

## CHAPTER 10. COMPOSITING CIRCUITS

### 10.1 Organization of a Phantom Circuit

The most expensive part of the equipment of telegraph-telephone communications is the line installation. Hence, from the very beginning of the development of intercity communications effort was made to make the best use of lines by "compositing" them (that is, organizing on a single two-wire circuit as many communications as possible).

One of the simplest methods of compositing is the use of a supplementary circuit, known as a phantom circuit, which permits the simultaneous conduct of three telephone conversations along two pairs of wires.

The supplementary circuit is formed by connecting telephones $T_5$ and $T_6$ to the midpoints of line transformers $LT_1$ and $LT_2$ through separate transformers $LT_3$, as shown in Figure 10.1. The circuits of telephones $T_1$-$T_2$ and $T_3$-$T_4$ are referred to as the main circuits and the circuit of telephones $T_5$-$T_6$ is referred to as the phantom circuit.

At the midpoints of line transformers $LT_1$ and $LT_2$ telephone current $I_t$ in the supplementary circuit branches in two, so that in each half of the winding of a transformer the current flows in the opposite direction. As a result the magnetic fluxes created in these transformers cancel out and cause no interference with telephone conversation on the main circuits.

In order to avoid interaction between the main and supplementary circuits it is necessary that the wire of each of the circuits be of the same material and have the same diameter and insulation. Supplementary circuits find wide use on cable lines, but they are rarely used on overhead lines.

10.2. Midpoint Compositing of Circuits

Another simple method of compositing a circuit is the midpoint compositing of simultaneous telephony and telegraphy. Figure 10.2 shows the scheme permitting simultaneous telephone and telegraph operation.

In this arrangement line transformers with a tap at the center of the line winding (the midpoint) are connected in the line at both ends of a telephone circuit. Telegraph instruments TG are connected to the midpoints. Upon depressing the key at telegraph instrument $TG_1$, telegraph currents pass through the line semi-windings of $LT_1$ in opposite directions, hence their magnetic fields cancel each other and do not cause interference in telephone $T_1$. The telegraph currents continue to flow in one direction along both conductors, through the line semi-windings of transformer $LT_2$ to telegraph instrument $TG_2$, and return through ground to the battery of telegraph instrument $TG_1$.

Due to mutual canceling of the magnetic fields in the line semi-windings of $LT_2$, telephone $T_2$ is also free of interference.

The requisite condition for absence of interference from telegraph transmission in telephone transmission is the equality of telegraph currents in both wires. This condition is met when both wires of the circuit have identical electrical characteristics (resistance, insulation) or, in other words, when the telephone circuit is symmetrical.

10.3 Compositing by Current Separation

There is also a method of simultaneous telegraph and telephone operation which is based on the principle of separating the electrical currents into different channels according to frequency.

For satisfactory transmission of human speech it is necessary that the elements of the circuit, including the line, pass without significant distortion currents with frequencies from 200 to 2,700 cycles. Analysis of the currents of telegraph transmission shows that they may be considered as consisting of alternating currents ranging in frequency from 0 to 80 cycles. The difference in the frequency bands required for transmission of telephone and telegraph currents permits applying the principle of separating the electrical currents into different channels according to frequency.

The use of this method is based on the fact that along a two-wire circuit currents may be transmitted which have a frequency difference within the approximate limits of 0 to 150,000 cycles or, as is said, within the frequency band from 0 to 150,000 cycles. Yet, for telegraph transmission the frequency band from

0 to 80 cycles is sufficient, and for transmission of human speech without significant distortion the frequencies may be limited to the band from 300 to 2,400 cycles. Hence the wide band of frequencies from 0 to 150,000 cycles which may be transmitted may be conveniently divided into several relatively narrow bands or, as is said, several channels may be isolated.

Separation of the channels in an electrical circuit is achieved by means of special units known as electrical filters, the purpose of which is to pass currents of given frequencies and block currents of all other frequencies.

Figure 10.3 shows an arrangement employing this principle to permit one telephone conversation and one telegraph hookup along a two-wire telephone circuit. In the figure the electrical filters passing only telephone currents are designated by K-0.1 and those passing only telegraph currents are designated by D-0.1.

In employing this principle for the transmission of several telephone conversations along a single circuit use is made of special "carrier-frequency" apparatus. The term "carrier frequency" is derived from the fact that alternating currents of certain previously chosen frequencies are used to "convey" telephone conversations. The oscillations of the speech currents are superimposed on the current of the chosen carrier frequency and transmitted along the line in the form of currents whose frequency is closer to that of the carrier current than to the frequency of the original speech current. In other words the carrier-frequency apparatus serves to shift the speech currents to another band of frequencies which is higher than the maximum frequency of the speech current.

If several carrier frequencies are chosen which are sufficiently removed from one another so that the speech currents superimposed on them are not subject to mutual interference, we may simultaneously transmit along one line several carrier frequencies and their superimposed speech currents independently of one another, as though the speech currents were being transmitted along separate circuits.

Having found a method whereby at the receiving end of the line we may separate the frequencies carrying the telephone conversations and extract from them the speech currents in their original form, we may create a system permitting the simultaneous transmission of as many conversations as we have carrier frequencies. The process of superimposing speech currents on a carrier frequency is achieved by means of a special device known as a modulator. The process of extracting the speech currents from the carrier frequency is achieved by means of a device known as a demodulator. The problem of separating frequencies is solved by means of electrical filters.

The apparatus by means of which it is possible to achieve several simultaneous telephone conversations on one line is known as a high-frequency line-compositing apparatus.

Figure 10.4 shows the basic diagram for compositing a line with three high-frequency telephone channels. For transmission of speech from the three subscriber telephone transmitters at station A to the three subscriber telephone receivers at station B three carrier frequencies are employed: $f_1$, $f_2$, $f_3$. Electrical filters $F_1$ will pass only carrier frequency $f_1$ with its superimposed speech of subscriber one, filter $F_2$ will pass only carrier frequency $f_2$ with its superimposed speech of subscriber two, etc.

For transmission of speech from the subscribers of station B to the subscribers of station A carrier frequencies $f'_1$, $f'_2$, and $f'_3$ are employed, as well as filters $F'_1$, $F'_2$, and $F'_3$ which pass their corresponding frequencies with the associated speech.

There is now in use apparatus permitting several simultaneous telephone and telegraph transmissions along a single overhead communications line. Apparatus for 3- and 12-channel compositing has found the widest use in telephone transmission.

When necessary, multiplex telegraph apparatus may be employed to provide 18 telegraph links along a single telephone channel.

## SECTION III. OVERHEAD COMMUNICATIONS LINES

## CHAPTER 11. CLASSIFICATION OF OVERHEAD COMMUNICATIONS LINES

### 11.1. Influence of Meteorological Conditions on Overhead Communications Lines

A conductor suspended between two supports is subject to loading due to its own weight, wind pressure, and icing. The loading rises especially sharply on the conductor, rigging, and supports when icing is accompanied by wind. Under icing conditions a sheath of ice covers the conductor. The formation of ice may be due to various causes. One of them consists in the fact that drops of rain, in falling from the clouds to earth, pass through an air layer with a temperature below 0° C and are cooled to a temperature below 0° C. In falling on solid objects these drops of cold water are quickly turned to ice and cover these objects

with a transparent sheath of ice. A deposit sometimes appears on the conductors in the form of fine needles of ice with a milky white color (hoarfrost). Most often the ice formations are stratifications of solid ice and hoarfrost.

With the wind blowing in the longitudinal direction of the line the ice deposit is usually uniform along the circumference of the conductor. If the wind pressure is transverse or at an angle to the line and drops of water strike the leeward side of the conductor, then ice will be formed on one side of the conductor. The greatest layer of ice usually forms on the groundward side of the conductor. The layer of ice may attain a diameter of 1 to 5 cm. In certain districts cases have been observed where the diameter of the ice reached 6-7 cm.

The maximum intensity and extent of icing is usually repeated in specific districts, which are therefore most unsuited for operation of overhead lines. In the European part of the USSR such a district is the entire territory lying south of the line between Khar'kov, Voronezh, and Saratov. The additional loading of conductors due to icing runs from 0.4 to 1.4 kg per meter, and in individual cases is greater. If icing is accompanied by strong wind, loading of conductors increases still further and the lines, crossarms, hooks, pins, and even poles are broken.

Icing is sometimes accompanied by wind speeds up to 15-20 m/sec. Wind speed may be determined from the scale given in Table 11.1.

TABLE 11.1

WIND-SPEED SCALE

| Observation without instrument | Wind designation | Wind speed in balls | Wind speed in m/sec |
|---|---|---|---|
| Smoke rises vertically, leaves still | calm | 0 | 0-0.5 |
| Wind direction ascertained from smoke | light air | 1 | 0.6-1.7 |
| Wind felt on face; leaves rustle | light breeze | 2 | 1.8-3.3 |
| Leaves and small twigs in constant motion | gentle breeze | 3 | 3.4-5.2 |
| Wind raises dust, moves small branches | moderate breeze | 4 | 5.3-7.4 |
| Small trees sway | fresh breeze | 5 | 7.5-9.8 |
| Large branches in motion, telegraph wires whistle | strong breeze | 6 | 9.9-12.4 |
| Tree trunks in motion, large branches bend, wind resistance felt in walking | moderate gale | 7 | 12.5-15.2 |
| Wind breaks small twigs and dry branches, interferes with breathing | fresh gale | 8 | 15.3-18.2 |
| Slight damage; wind removes chimney pots and roof tiles | strong gale | 9 | 18.3-21.5 |
| Considerable damage, trees uprooted | whole gale | 10 | 21.6-25.1 |
| Widespread damage | storm | 11 | 25.2-29.0 |
| Widespread damage | hurricane | 12 | greater than 29.0 |

Ice or hoarfrost deposits on conductors do not merely affect the mechanical strength of a line. Power losses increase in the

presence of an ice layer on the conductor, that is, current attenuation in the line circuit increases. The higher the frequency of the current, the greater the current attenuation in the circuit. With certain amounts of ice deposits the high-frequency channels begin to malfunction and with an increase in the deposit communications may break down. With the appearance of ice or hoarfrost on conductors line-engineering personnel must take timely steps for the removal of these deposits.

## 11.2. Types of Overhead Communications Lines

In order to prevent breaks in conductors and damage to poles due to wind and ice communications lines are designed with these loads in mind and are erected according to the type specifications given in Table 11.2

TABLE 11.2

TYPES OF COMMUNICATIONS LINES AND THEIR CHARACTERISTICS

| Type of line | No of supports per km | Length of span in meters | Characteristics (meteorological conditions) of the district |
|---|---|---|---|
| O (light loading) | 20 | 50 | Non-icing or with icing with average radial thickness up to 5 mm, or with hoarfrost with radial thickness up to 20 mm. |
| N (medium loading) | 20 | 50 | Icing with average radial thickness up to 10 mm inclusive, or with hoarfrost with radial thickness greater than 20 mm. |
| U (heavy loading) | 25 | 40 | Icing with average radial thickness up to 15 mm incl. |
| OU (extra heavy loading) | 28 | 35.7 | Icing with average radial thickness up to 20 mm incl. |

The various types of lines are also distinguished according to the auxiliary fastenings of the supports, the diameters of supports, et al (as explained in Chapter 12).

## 11.3. Classification of Overhead Communications Lines

According to their importance, overhead communications lines are divided into three classes:

First Class -- lines of all-union importance (trunk lines), linking Moscow with the republic, oblast, and kray centers, and interconnecting the republic, oblast, and kray centers.

Second Class -- lines linking the republic, oblast, or kray centers with the rayon centers, and interconnecting the rayon centers.

Third Class -- lines of intra-rayon communications.

# CHAPTER 12. POLES AND THEIR INSTALLATION

## 12.1. Pole Construction. Materials Used in Preparing Poles.

The poles used in communications lines are distinguished according to their location on the line, their construction, and their purpose.

According to their location on the line, poles are classed as:

- intermediate -- on which the direction of the conductors does not change;
- corner -- on which the conductors change direction;
- terminal -- on which overhead communications lines begin or end.

According to construction, poles are classed as: single, compound, with reinforcement.

According to use, poles are classed as: anchor, semi-anchor, sectional, cable, crossing, anti-wind, and test.

Poles for overhead communications lines are wooden or of reinforced concrete.

Reinforced-concrete poles have a number of advantages over wooden poles: (1) they are more economical, since their service life is approximately four times greater than that of wooden poles; (2) they do not require additional maintenance; (3) most important of all, they permit conservation of wood.

In the production of reinforced-concrete poles the following materials are used: Portland cement, puzzuolanic cement, steel reinforcements, wire rods, sand, gravel (or crushed stone), and water.

Reinforced-concrete poles are made at present in plants, concrete yards, or at line-technical units by the vibration method or the centrifugation method. With the vibration method poles of differing cross-section may be made. The centrifugation method is used in making tubular poles. Such tubes (sections) come in 6- and 3-meter lengths and may be used for stringing of 16 conductors with conductor clearances of 3 and 4.5 m.

The standard pole consists of a section with an outside diameter of 200 mm and a length of 6 m, whereas the lengthened pole (clearance 4.5 m) consists of one 6-meter section with an outside diameter of 200-300 mm and one 3-meter section with a diameter of 300-400 mm.

The sections of the lengthened pole may be joined telescopically with the application of a cement solution (in this case in assembling the pole 0.5 m of the overall length is lost and the length of the pole is 8.5 m) or the sections are joined by the electric welding of two rings embedded in the sections (in this case the overall height of the pole is 9 m).

The following types of trees are used in making wooden poles: pine, larch, cedar, spruce, and fir.

The dimensions of logs for poles and attachments are given in Table 12.1. Table 12.2 gives the weight of various sizes of moist pine poles.

TABLE 12.1

PRINCIPAL DIMENSIONS OF LOGS (POLES)

FOR SUPPORT OF COMMUNICATIONS LINES

| Purpose of poles | Length, m | Thickness at upper end, cm | Grade |
|---|---|---|---|
| Poles for support of communications lines | 6.5, 7.5, 8.5, 9.5 | 14-24 | 2 and 3 |
| Poles for support of communications lines | 11, 13 | 18-24 | 2 and 3 |
| Logs for attachments | 2.75, 3.25, 3.5 | 16-26 | 2 and 3 |

TABLE 12.2

WEIGHT OF MOIST PINE POLES, kg

| Length of pine pole, m | Diameter of pole at upper end, cm | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 6.5 | 62 | 71 | 81 | 92 | 103 | 115 | 127 | 142 | 156 | 170 | 185 | 202 | 218 |
| 7.5 | - | - | 100 | 113 | 127 | 110 | 156 | 172 | 188 | 200 | 211 | 244 | 266 |
| 8.5 | - | - | 117 | 132 | 147 | 164 | 181 | 199 | 218 | 239 | 259 | 281 | 304 |
| 11 | - | - | - | - | - | - | 261 | 286 | 311 | 336 | 366 | 396 | 425 |
| 13 | - | - | - | - | - | - | 337 | 372 | 402 | 438 | 474 | 510 | 546 |

The poles are prepared during the winter and are stored in piles on elevated sites not subject to flooding. The bark must be removed from the poles before storage. The site on which the poles are to be stored must first be cleared of bark and debris, and in the winter it must be cleared of snow.

The first layer of poles is placed on sleepers. Between layers planks or beams are wedged between the outermost poles. After completing the pile the top layer is covered with flats or battens.

12.2. Defects of Wood

The various diseases and faults of wood due to fungi, insects, and natural conditions are referred to as wood defects. Defects of one or another type result in wood of poor quality. A state standard specifies the limits of permissible defects. The defects discussed below relate only to poles for overhead communications lines.

Loose knots and tobacco knots are not permitted. A loose knot is a fully or partially rotted knot still retaining its form. The color of the knot varies and is sometimes impregnated with black or white spots. Among the loose knots is the black resinous knot of hardwoods, consisting of a black mass of resin. Friable black knots are a defect of softwoods (for example, of the birch) and are included among the loose knots. The tobacco knot is a completely rotted knot. It is a chestnut-colored, brown, or mottled (in softwoods it is sometimes white) mass which crumbles easily under manual pressure. Tobacco knots are usually due to internal rotting of the tree trunk and may be regarded as a sign of such.

"Pasynki" are not permitted. A pasynok is a thick, protracted knot of oval form. It extends at a very small angle to the axis of the trunk and penetrates deeply within the trunk. In most cases the pasynok marks a halting point in the growth of the tree or a dead secondary crown.

Internal and sapwood discoloration (any rots) are not permitted.

Internal discoloration is encountered in all coniferous wood and deciduous heartwood. It is observed at the ends in the form of large, variform spots, rings, or holes, and on the sides in the form of bands. The color of the diseased wood is extremely diverse: rose, red, reddish, brown, gray, and sometimes black or violet.

Sapwood discoloration, like internal discoloration, is encountered in all coniferous wood and deciduous heartwood. In conifers the color of the diseased wood is pale yellow, light brown, or sometimes has a reddish tinge. In elm and fir the discoloration often penetrates seasoned wood.

Sapwood rot is the final stage of wood rot due to the fungi causing sapwood discoloration. Sapwood rot takes the form of an external ring of rotted wood at the ends of logs and is light brown, pale yellow, or white in color. Wood affected by sapwood rot may be detected by pressure and crumbles easily along the grain. Sapwood rot forms on felled timber and dead trees. Rot develops in unseasoned logs stored under unfavorable conditions and may spread to seasoned wood or partially to the core, whereupon the strength of the affected portion is considerably lowered.

Marbled rot is characterized by the fact that against the background of a browned, "stewed" wood (stored in the hot time of year) discolorations appear in the form of spots and bands, sometimes delimited by twisting black and black-brown lines. The affected portions are marble-like in appearance.

External rot is encountered in all types of wood. It develops under unfavorable storage conditions. The decay begins from the outer part of the heart or sapwood and gradually penetrates the wood. Sometimes the disease begins within the wood when the spores of fungi enter through external cracks. At first the wood is discolored a light brown, then it becomes brown or dark brown. Transverse and longitudinal cracks appear and the wood disintegrates into prismatic fragments which are easily crumbled into powder.

Internal rot is encountered in all types of wood. For the most part it represents the final stage of affliction of the growing tree with destructive fungi.

Frost fissure with fungus is not permitted. Frost fissure is often encountered in softwood trunks and sometimes in hardwoods. Frost fissure is an external longitudinal crack gradually narrowing down to the center of the trunk. Usually along the edges of the crack there are ridges from growth of the wood and bark. Frost fissures overgrown on the outside with dense layers of wood are sometimes encountered.

The multi-side bend is not permitted in grade 2; for grade 3 it is permitted for not more than 2 percent of the length of the log. The bend is a deformation of the trunk. If the deformation is directed to one side, the bend is a one-side bend, but if it is in various directions, it is a many-side bend.

## 12.3. Methods of Prolonging the Service Life of Poles

The service life of wooden poles is a very important economic index. It determines the amount of the input and outlay of wood for maintaining poles in satisfactory condition. It is natural that frequent replacement of poles necessitates the preparation of timber and large expenditures.

The service life of poles is affected principally by climatic conditions of the locality in which they are installed, the nature of the ground, and the type of wood. Decay is caused by fungi which, getting into the wood, use it as a source of food and gradually destroy it. The rapid decay of wood depends largely on the degree of atmospheric humidity and temperature conditions: a dry wood or one permanently located in water, as a rule, does not decay, while wood located under conditions of varying moisture (30-60 percent) may be destroyed in three or four years.

Decay of the poles does not occur uniformly over their length. The greatest decay of poles and attachments is observed at ground level and below (approximately 30-40 cm above and below ground level), and also at the top and at points of connection with attachments and other components.

Protection of the wood against decay consists in impregnating it with such substances as will prevent the development of fungi, that is, stop their activity. Substances which are poisonous for fungi are known as antiseptics. Antiseptics fall into two basic groups: emulsive (coal-tar oil, anthracene oil, shale oil, and various resins) and water-soluble (sodium fluoride, uralite, triolite, zinc chloride, copper sulfate, arsenical and arsenide compounds, etc).

Antiseptics are applied to the wood in amounts sufficient to prevent the development of destructive fungi, the precise amount depending on the toxicity of the antiseptic. They are applied to the wood by different methods. These methods may be divided into two basic groups -- simplified methods and plant methods employing pressure and exhaustion (vacuum).

Applied under the proper conditions, plant methods provide treatment of high quality. The simplified methods do not require complex plant equipment, with the result that treatment by these methods may be organized both in treating yards and at the site of pole installation. The most generally used method of treating poles for overhead communications lines is the band method. The service life of poles treated by the plant method is 25-30 years, by the simplified band method it is 12 years.

The band method is used in treating poles and attachments of all types of wood except oak and deciduous. With this method the poles are treated directly on the line by applying the antiseptic mass to the pole butt or attachment with subsequent waterproofing of this portion of the pole. The composition and amount of paste for a single band are given in Tables 12.3-12.5.

TABLE 12.3

COMPOSITION AND AMOUNT OF PASTE IN SULFITE LIQUORS

| Band dimensions, cm | | Sodium fluoride (g) | Extract of sulfite liquors (g) | Water ($cm^3$) | Approximate amount of paste per coat ($cm^3$) |
|---|---|---|---|---|---|
| width | circumference | | | | |
| 60 | approx. 50 | 380 | 73 | 160 | 360 |
| 60 | approx. 65 | 420 | 81 | 176 | 400 |
| 60 | approx. 80 | 600 | 116 | 252 | 570 |
| 60 | approx. 100 | 750 | 145 | 314 | 710 |

TABLE 12.4

COMPOSITION AND AMOUNT OF BITUMINOUS PASTE

| Band dimensions, cm width | circumference | Sodium fluoride (g) | Bitumen (g) | Solvent (kerosene, etc) ($cm^3$) | Approximate amount of paste per coat ($cm^3$) |
|---|---|---|---|---|---|
| 60 | approx. 50 | 380 | 138 | 173 | 530 |
| 60 | approx. 65 | 420 | 153 | 191 | 590 |
| 60 | approx. 80 | 600 | 218 | 273 | 840 |
| 60 | approx. 100 | 750 | 273 | 314 | 1,050 |

TABLE 12.5

COMPOSITION AND AMOUNT OF PASTE IN COAL-TAR VARNISH "B"

| Band dimensions, cm width | circumference | Sodium fluoride (g) | Coal-tar varnish "B" (g) | Water ($cm^3$) | Approximate amount of paste per coat ($cm^3$) |
|---|---|---|---|---|---|
| 60 | approx. 50 | 380 | 242 | 69 | 490 |
| 60 | approx. 65 | 420 | 267 | 76 | 545 |
| 60 | approx. 80 | 600 | 380 | 109 | 778 |
| 60 | approx. 100 | 750 | 477 | 136 | 970 |

When uralite or triolite is used the amount required is 20 percent less than for sodium fluoride. The other substances entering into the composition of the paste are also reduced by 20 percent.

Pastes are made in various ways, depending on the composition.

Paste in an extract of sulfite liquor (sulfite wash, foundry concentrate). A finely ground extract of sulfite liquors is dissolved in hot water in half the amount indicated in Table 12.3. The sizing may be stored for several days. After this it is necessary

to add the antiseptic and the remaining portion of the water to the sizing solution in small amounts. The mixture is then carefully stirred until the ingredients are thoroughly mixed.

Bituminous paste. A finely ground bitumen is placed in a vat and melted over a low flame with frequent stirring. After the bitumen is melted the fire is put out. With the bitumen at a temperature of approximately 90 degrees the solvent is gradually added during constant stirring. To the resulting solution add small quantities of the antiseptic during constant stirring until the ingredients are thoroughly mixed.

Paste in coal-tar varnish "B". Add the antiseptic to cold water and stir thoroughly, then pour a double portion of coal-tar varnish "B" and stir the mixture for 20-30 minutes.

For waterproofing of the paste, apply a waterproofing substance over a foundation (tar paper, ruberoid). The waterproofing substance will contain a bitumen of grade 3 or 4 (65%) and kerosene or a polychloride of benzene or of solvent naphtha (35 percent), just as in the preparation of bituminous paste. Instead of the bitumen solution, use may be made of a resin (coal tar, wood resin, peat tar, etc with a water content of not more than 5 percent) or coal-tar varnish "B" without any additives.

The pole butt or attachment is protected by a single band. In those rayons where decay of the pole is observed over the entire underground portion two bands are applied.

In the band method the pole is treated in the following manner: the pole is placed so that its butt is raised on a wooden

block over the hole; a uniform coat of paste is applied by brush to the portion of the pole which is to be protected; then a piece of tar paper is placed under the butt end of the pole and is firmly wrapped around the pole by pressing from the bottom up.

After fastening the band with roofing nails and wrapping it with wire 1-1.5 mm in diameter, the surface of the band and the areas 3 cm above and below the band are coated with waterproofing. In fitting a single band it is fastened so that the upper edge is 10 cm above ground. Where two bands are fitted the second band is fastened so that it extends 10 cm below the lower edge of the first band.

In swampy localities where the pole decays above the surface a single band is placed so that its lower edge is at the surface and not less than 10 cm from the ground.

The tops of poles and attachments, the different types of gains or notches, as well as the holes for pins and bolts are protected against decay by smearing them with creosote or anthracene oil tars. In regions where rapid decay of pole tips is noticed they are treated with antiseptic paste. A band is applied to the top. The band is punctured at approximately ten places and roofing nails are driven with discs of tar paper or paper beneath them.

In order to prolong the service life of treated poles, at the first signs of decay the band treatment must be repeated, for such treatment increases the service life of the poles by 2-3 times, which permits a considerable saving of wood.

The antiseptics used for pole treatment are poisonous to the human organism. Upon coming in contact with the skin, they cause irritation and result in sores requiring long periods of medical treatment. Antiseptics accidentally entering the organism cause poisoning. Hence, in treating poles it is necessary to work in overalls. Upon stopping work the overalls must be removed and kept apart from personal clothing in special cabinets.

Contamination of the hands and body is not permitted. The hands and body must be washed after work. Food may be eaten only after removing the overalls and carefully washing the hands. Work must not be performed on creosote-treated poles while the shirt collar is open, nor must such poles be climbed without long gloves. In order to prevent poisoning of livestock, antiseptic which has been spilled and is not easily washed away and contaminated grass and scraps of material from band treatment must be gathered by shovel at the conclusion of work and buried in a pit not less than a half meter deep. The remaining area must be spaded.

## 12.4 Intermediate Poles

An intermediate pole is subject to loading by lateral wind pressure on the conductors hung from it and on the pole itself. The pole's section of greatest stress is at ground level.

Typical pole profiles and the number of circuits are given in Figure 12.1. Pole dimensions and setting depths are given in Tables 12.6 and 12.7.

On lines of types O and N with conductors strung on hooks the spacing between conductors must be 40 cm and on lines of types U and OU 60 cm. Dimensions of wooden poles with conductor spacing of 40 cm are given in Table 12.6 and dimensions of poles with conductor spacing of 60 cm are given in Table 12.7.

TABLE 12.6

PRINCIPAL DIMENSIONS OF WOODEN POLES AND SETTING DEPTHS

WITH CONDUCTOR SPACING OF 40 CM

| No of conductors on pole with clearance in m | | Profile number | Overall length of pole in m | Minimum diameter of pole at top (cm) for lines of type | | Setting depth in m |
|---|---|---|---|---|---|---|
| 2.5 | 3 | | | O | N | |
| 8 | 6 | 1 | 6.5 | 12 | 14 | 1.3/1.2 |
| 12 | 10 | 1 | 7.5 | 12 | 15 | 1.4 |
| 16 | 16 | 1 | 8.5 | 14 | 17 | 1.6 |

In soft ground and on the sides of hills with slopes greater than 45 degrees the setting is increased by 15 cm. In stony and rocky ground the setting depth is 0.9 m for poles 6.5 m long and 1.1 m for poles 7.5 and 8.5 m long.

[See Table 12.7 Following Page]

TABLE 12.7

PRINCIPAL DIMENSIONS OF WOODEN POLES AND

SETTING DEPTHS WITH CONDUCTOR SPACING OF 60 CM

| No of conductors | Profile number | Overall length in m | Minimum diameter of pole at top (cm) for lines of type O | N | U | OU | Setting depth in hard or swampy ground in m |
|---|---|---|---|---|---|---|---|
| 4/6* | 1 | 6.5 | - | - | 12 | 13 | 1.2 |
| 8 | 1 | 7.5 | - | - | 13 | 15 | 1.4 |
| 10 | 1 | 8.5 | - | - | 15 | 16 | 1.5 |
| 12 | 5 | 8.5/7.5* | 12 | 14 | 16 | 19 | 1.5/1.4 |
| 16 | 2,6 | 8.5/7.5 | 14 | 17 | 18 | 20 | 1.6/1.5 |
| 20 | 3,7 | 7.5** | 15 | 18 | 19 | 21 | 1.5 |
| 24 | 4 | 6.5 | 16 | 18 | 19 | 22 | 1.5 |
| 32 | 4 | 7.5 | 18 | 22 | - | - | 1.6 |
| 40 | 4 | 8.5/7.5 | 20/19 | 25/23 | - | - | 1.8/1.7 |

* Numerator indicates pole length with clearance of 3 m, denominator indicates pole length with clearance of 2.5 m.

** In profile No 7 for lines with clearance of 3 m pole length is 8.5 m.

An intermediate pole of centrifugated reinforced concrete with a conductor clearance of 3 m is shown in Figure 12.2; such a pole with a clearance of 4.5 m is shown in Figure 12.3. As the figure shows, these poles are designed for crossarm stringing only with up to 16 conductors. The weight and diameter of reinforced-concrete poles are given in Table 12.8.

Joining of 6,000- and 3,000-mm sections is done telescopically; that is, with the lower section installed in the ground, the upper section is placed on the support ring and the space between sections is filled with cement (Figure 12.3).

TABLE 12.8

DIMENSIONS OF CENTRIFUGATED

REINFORCED-CONCRETE SECTIONS

| Outer diameter mm | Inner diameter mm | Length of section mm | Weight of section kg |
|---|---|---|---|
| 200 | 130 | 6,000 | 275 |
| 300 | 220 | 6,000 | 500 |
| 300 | 220 | 3,000 | 250 |
| 400 | 320 | 3,000 | 338 |

## 12.5. Compound Poles and Poles with Reinforcement

Semi-anchor poles (Figure 12.4) (consisting of two vertical poles, two braces against them, one diagonal brace, and two underground crossbeams) are installed as crossing poles in crossing rivers, gullies, highways, and railroads; they are also used as entrance and cable poles.

Semi-anchor, reinforced, and anti-wind poles are used to increase line stability on straight runs. They are installed when the number of conductors to be strung is greater than six and only on lines of types U and OU. On lines of type N they are installed for 24 conductors or more, one every 3 kilometers.

Semi-anchor poles are used only when the conductors are strung on crossarms. If the conductors are strung on hooks, reinforced poles are used; these differ from the intermediate poles in that they are strengthened by two braces located parallel to the line.

Anchor poles are used in erecting lines with reinforced-concrete poles. Such a pole consists of two intermediate poles

(Figure 12.2 or 12.3). If an anchor pole is used to strengthen a line, it is reinforced by four guys directed along the line. When the anchor pole is a terminal pole, it is reinforced by two guys opposing the pull of the conductors. Guys are fastened to the pole with a special collar of strip steel.

An anti-wind pole (Figure 12.5) consists of a pole and a brace with a crosslog. The anti-wind pole is erected on the line so that the brace is perpendicular to the line. The braces are located alternately on one side of the line and then the other. The brace and crosslog are fastened with bolts so that the pole resists the wind in any direction.

The arrangement of anti-wind, semi-anchor, reinforced, and anchor poles is shown in Figure 12.6.

A sectional, reinforced-concrete, anti-wind pole consists of an intermediate pole (Figure 12.2) reinforced by two guys perpendicular to the direction of the line.

In swampy grounds all poles are reinforced by two braces joined by sleepers. The braces are placed in a straight line in the plane perpendicular to the line, and at an angle as in ordinary angle braces (Figure 12.7).

A corner pole is used at a point of change in direction of line. In addition to the loads acting upon an intermediate pole, the corner pole is subject to additional loading due to side pull of the conductors at the bend in the line. This additional loading is the resultant force of the conductor stress. The greater the angle of deflection and the greater the conductor loading (ice, wind), the greater the resultant force.

In overhead communications lines, instead of the angle of deflection, the expression "normal departure of angle" is used. By "normal" departure of angle is meant the length of the perpendicular from the vertex of the angle formed by extensions of the conductors strung on an angle pole to a straight line joining two points of the line of conductors, each of which points is 50 meters away from the vertex of the angle (Figure 12.8). The normal departure must not exceed 15 meters, which corresponds to an inner angle of 145 degrees or an angle of delection of 180 - 145 = 35 degrees.

Before stringing the conductors a corner pole is reinforced with braces or guys.

Braces and guys are installed in the direction of resultant stress of the conductors and must not interfere with pedestrian or transport traffic. Guys are used when reinforcement with a single brace is inadequate or when it is not possible to install a brace. Centrifugated reinforced-concrete poles are reinforced with guys.

A general view of reinforcement of a corner pole with a brace is shown in Figure 12.9. In order that the top of the brace will fit snugly against the pole a grooved depression is made in it. The depth of the depression depends on the diameter of the pole. The area of contact of the brace with the pole is smeared with creosote. The diameter of the brace must not be less than four-fifths the diameter of the base pole. The upper end of the brace is fastened under the third or fourth hook or under the third crossarm, counting from the top of the pole.

Instead of a bolt, line wire with a diameter of not less than 4 mm may be used to fasten the logs to a corner pole.

A general view of a pole reinforced with a guy is shown in Figure 12.10.

The guys are made of new steel line wire with a diameter of 4 or 5 mm. The number of strands is determined by calculation or from the tables given in Pravila proyektirovaniya, stroitel'stva i remonta vozdushnykh liniy svyazi [Rules for Designing, Erecting, and Repairing Overhead Communications Lines] (Svyaz'izdat, 1952). For twisting of guy wires, two poles are installed at a distance twice the length of the guys to be made up and between them the appropriate number of strands are run off. The wire is passed through evenly spaced openings in a circle on a special plate; rotation of the latter twists the strands (guy).

When up to eight conductors are to be placed on hooks the upper end of the guy is fastened beneath the third hook and when up to twelve conductors are to be so placed the upper end of the guy is fastened beneath the fifth hook -- counting from the top of the pole. When the conductors are to be placed on crossarms the upper end of the guy is fastened beneath the second crossarm from the top.

Pole guys are fastened in the following manner:

two full wraps of the upper end of the guy wire are made around the pole (Figure 12.11) and one of the strands at the end of the wire is bent back, while the rest of the strands are pressed snugly against the main guy wire;

the strand which was bent back is firmly wound around the main guy and the adjacent end piece with not less than five turns; the remainder of the strand is clipped off;

a second strand is bent out and wrapped around the guy wire and the remaining strands with not less than five turns; this procedure is followed with each of the remaining strands.

With not more than six conductors to be strung the guy may be fastened to the pole with line clamps. With a large number of conductors the guy is fastened with a barge spike or lag screw driven into the upper part of the pole directly beneath the guy wires.

Guys on a centrifugated reinforced-concrete pole are fastened with a collar of strip steel.

The lower end of the guy is fastened to an anchor by means of pulleys which are fastened at one end to the anchor strap and at the other to the guy wire. The guy wire is drawn up and passed through the loop of the anchor strap; the end is then untwisted and pressed to the main guy. The rest of the fastening proceeds in the manner described above.

The wire strap for the anchor (Figure 12.12) is a twist of steel strands of the same diameter as used in the guy. There are twice as many strands in the strap as in the guy. The twist of the strap is in the same direction as the twist of the guy.

Anchor logs must be made of sound wood. The sound part of old poles may be used for this purpose. Log dimensions and setting depths are given in Table 12.9.

In rocky ground where it is not possible to dig a hole the guy wire is fastened to a steel rod cemented in the ground. The cement solution contains cement and sand in a ratio of 1:3.

In order to fix guy wires in soft ground a three-log arrangement is used.

If the guy wire must be carried over a road or any obstacle, then guy poles (Figure 12.14) are used. The guy pole is set at the same depth as the main pole and is reinforced with counter-guying. Two counter-guys are attached to this pole at a height of 3 meters above ground.

TABLE 12.9

LOG DIMENSIONS AND SETTING DEPTH

| No of strands in a guy with a diameter of 4 mm | 5 mm | Log length cm | Log diameter cm | Setting depth m |
|---|---|---|---|---|
| 4 | - | 120 | 15 | 1.1 |
| 6 | 4 | 120 | 18 | 1.2 |
| 9 | 6 | 150 | 20 | 1.3 |

The distance of the anchor of a counter-guy from the base of the guy pole must be equal to the height of the guy pole. Beneath the butt end of a guy pole installed in weak ground crushed stone or a foot plate is placed.

Beneath the butt ends of reinforced-concrete poles in all grounds except craggy or rocky ground it is necessary to place logs, and in swampy localities it is necessary to insert a wooden plug into the tubular butt of the pole in order that water will not enter the tube of the reinforced-concrete pole.

Test poles are designed for testing and locating faults along conductors. They are erected at railroad stations at points convenient for servicing. On lines along paved roads and dirt roads they are erected at the buildings of test points and communications enterprises or near the residence of a line inspector. Corner poles must not be used as test poles, and adjacent spans

must be identical. The test pole differs from the usual intermediate pole in that it is equipped with test straps if the conductors are strung on crossarms or with test brackets if the conductors are strung on hooks.

The line conductors are strung from a test pole in the following manner. The conductors are cut and the end of each is wrapped around the neck of an insulator and fastened with a dead-end tie. Steel conductors are fastened by means of a binding wire, and nonferrous conductors are fastened by means of copper sleeving. Stranded aluminum-clad steel conductors are fastened by means of aluminum sleeving. The ends of the line conductor used for the connection are tinned and wrapped 2-3 times around the conductor, then they are turned up as shown in Figure 12.15. The turns of the left and right ends of the conductor must be made in opposite directions. Both ends of the line conductor are connected and disconnected during tests by means of a test clamp, a general view of which is given in Figure 12.16.

If the conductors are placed on crossarms, then for convenience in testing the conductors an additional crossarm (without pins) is mounted on the test pole. With one or two crossarms the additional crossarm is mounted 60 cm below the second crossarm. If there are more than two crossarms, the additional crossarm is mounted 60 cm below the last one.

The test pole must be equipped with a lightning arrester.

In populated localities and in establishing crossings, when the size of the main poles are such that the necessary clearances are not provided, longer poles are erected or poles with reinforced-concrete or wooden attachments are erected.

The following types of reinforced-concrete attachments are produced:

a. single attachments of types PR-0, PR-1, PR-2, and PR-3 (Figure 12.17) installed singly or in two's at the pole;

b. paired attachments (with light-duty reinforcement) of types SPR-21, SPR-22, and SPR-23 installed in two's at the pole (Figure 12.18).

Dimensions and weights of the attachments are given in Table 12.10.

TABLE 12.10

DIMENSIONS AND WEIGHTS OF REINFORCED-CONCRETE ATTACHMENTS

| attachment | Dimensions cm | Diameter of reinforcement, mm | attachment, kg |
|---|---|---|---|
| SPR-21 | 8x10x270 | 6 | 55 |
| SPR-22 | 12x10x280 | 6 | 84 |
| SPR-23 | 16x10x290 | 6 | 115 |
| PR-0 | 13x14x270 | 10 | 123.5 |
| PR-1 | 15x14x270 | 12 | 138 |
| PR-2 | 17x14x280 | 12 | 162 |
| PR-3 | 20x14x290 | 12 | 196 |

The types of reinforced-concrete attachments which must be used in reinforcing wooden poles according to height and number of conductors are given in Table 12.11.

TABLE 12.11

TYPES OF ATTACHMENTS FOR ERECTING WOODEN POLES

| No of conductors | Profile No | Overall length of pole with attachment m | Line types O | N | U | OU |
|---|---|---|---|---|---|---|
| | | | Types of attachments | | | |
| 4 | 1 | 6.5 | PR-0 | PR-1 | PR-1 | PR-1 |
| 6 | 1 | 6.5 | PR-1 | PR-2 | PR-2 | PR-2 |
| 8 | 1 | 7.5 | PR-1 | PR-3 | 2xSPR-23 | 2xSPR-23 |
| 10 | 1 | 8.5 | PR-2 | 2xSPR-23 | 2xSPR-23 | 2xSPR-23 |
| 12 | 5 | 8.5 | PR-3 | 2xSPR-23 | 2xPR-0 | 2xPR-0 |
| 16 | 2 | 8.5 | 2xSPR-23* | 2xPR-0 | 2xPR-0 | 2xPR-0 |
| 16 | 6 | 7.5 | 2xSPR-23 | 2xPR-0 | 2xPR-0 | 2xPR-0 |
| 20 | 3 | 7.5 | 2xPR-0 | 2xPR-0 | 2xPR-0 | 2xPR-0 |
| 20 | 7 | 8.5 | 2xSPR-23 | 2xPR-0 | 2xPR-0 | 2xPR-0 |
| 24 | 4 | 6.5 | 2xSPR-23 | 2xPR-0 | 2xPR-0 | 2xPR-0 |
| 32 | 4 | 7.5 | 2xPR-0 | 2xPR-1 | 2xPR-1 | 2xPR-1 |

* The numeral before the letters indicates that the pole is reinforced with two attachments.

In reinforcement with the attachments listed in Table 12.11 the length of span and the setting depth of the pole must correspond to the values given in Table 12.7.

If the reinforced-concrete attachment does not extend far enough into the ground, it is built down with a wooden piece fastened to it by means of a wire strap. The length of the piece is chosen according to the setting depth for the pole as given in Table 12.12.

TABLE 12.12

LENGTH OF WOODEN PIECE ACCORDING TO

SETTING DEPTH OF POLE

| Setting depth of pole, m | Length of piece, m |
|---|---|
| 1.4 | 0.7 |
| 1.5 | 0.8 |
| 1.7 | 1.0 |

A single wooden attachment fitted to a pole with a length of up to and including 8.5 m must be of the same diameter as the reinforced pole at the ground level (Figure 12.19) and a double wooden attachment must have a diameter equal to that of the top of the pole.

The wooden attachments are fastened to the pole in the direction normal to the line by means of wire straps. The wire of the straps is tightened by means of a special crowbar, care being taken not to overtwist the straps and break them. The number of turns in each strap is determined from Table 12.13.

Reinforced-concrete attachments are fastened to the pole along the axis normal to the direction of the line in such a way that the overhang of the attachment is facing the pole. These attachments may also be fastened to corner, semi-anchor, terminal, and other compound poles.

In loading, unloading, and hauling the attachments they must not be dropped, since the concrete may split and fine cracks or even visible cracks appear in the attachments.

Cracks in the concrete may considerably shorten the service life of the attachments by hastening weathering of the protective layer of concrete and corrosion of the reinforcing materials.

TABLE 12.13

NUMBER OF TURNS OF WIRE IN STRAPS

| Number of conductors | Type of line | Number of turns in strap 5 mm | 4 mm |
|---|---|---|---|
| 2-6 | O, N | - | 4 |
| 7-12 | O, N | 4 | 4 |
| 13-16 | O, N | 4 | 4 |
| 17-24 | O | 4 | 4 |
| 17-24 | N | 4 | 6 |
| 25-40 | O | 4 | 6 |
| 25-40 | N | 6 | 8 |
| 2-6 | U, OU | 4 | 4 |
| 7-12 | U, OU | 4 | 6 |
| 13-24 | U | 6 | 8 |
| 13-24 | OU | 8 | 10 |

Special care must be exercised in preparing the wooden piece (insert) to be installed in the lower (buried) part of the paired attachments, for with a piece of incorrect dimensions the attachments will bend when tied and cracks may appear in the concrete.

## CHAPTER 13. MATERIALS AND ACCESSORIES

### 13.1 Wire

An electrical circuit on overhead communications lines must provide transmission of communications signals over the necessary distance, that is, the conductor must possess the lowest possible electrical resistance. Moreover, the conductor must possess additional mechanical strength, for it is subject to loading due to its own weight, icing, and hoarfrost; it is subject to wind pressure; it is subject to temperature effects. With respect to these factors conductors must meet a number of requirements, the most important of which are the following:

the material of the conductors must possess the lowest possible electrical resistance, especially in the case of long-distance conductors on which high-frequency currents are transmitted;

the conductors must have high mechanical strength, they must be resilient, not brittle;

the service life of conductors must be as long as possible; that is, they must not corrode (disintegrate due to oxidation) when strung on the line.

These requirements are met by a bimetallic conductor having a steel core covered with copper (thickness of the copper coating is 0.2-0.4 mm) and a tensile strength of not less than 75 $kg/mm^2$; a steel-reinforced aluminum conductor (stranded) having a steel core with a diameter of 1.8 mm and a yield strength of 120 $kg/mm^2$ over which are wound six aluminum wires with a diameter of 1.8 mm each, as well as a hard-drawn copper wire with a tensile strength of 42-43 $kg/mm^2$. In line use this wire is covered with a layer of copper oxide beneath which further corrosion practically does not occur.

Steel wire is used for telephone communications over short distances. It has a rather high yield strength of 37-55 $kg/mm^2$. Due to the extremely sharp increase in resistance in transmitting high-frequency currents over steel conductors, they are used only for frequencies up to 25 kc (that is, for low-frequency telephony and three channels of high-frequency telephony).

The disadvantage of steel wire is its extreme susceptibility to rust. An increase in the service life of steel conductors is

achieved by galvanizing the conductors and also by adding copper to the steel. The service life of steel wire with a copper content (0.2-0.4 percent) is approximately 50 percent longer than wire without a copper content.

For the installation of the different types of principal crossings the strength of the line wire is inadequate. In a principal crossing span steel cables with a tensile strength of 140 kg/mm$^2$ are used instead of steel line wire, and stranded bimetallic conductor with a yield strength of 70-75 kg/mm$^2$ or bronzed wire is used instead of conductors of nonferrous metal.

Upon receiving wire at the plant for overhead communications lines it is inspected, its diameter is measured, and it is tested for tensile strength, bending, winding, and twisting in accordance with the prescribed technical specifications.

The technical specifications for line wire are given in Table 13. 1 and for binding and jointing wire in Table 13.2.

[See Table 13.1 Page No 64]

Steel line wire is fastened by means of galvanized soft steel wire. Wires of nonferrous metals (copper, bimetal) are fastened by means of soft copper wire. Steel-reinforced aluminum wire is fastened by means of aluminum wire with a diameter of 3 mm.

[See Table 13.2 Page No 65]

TABLE 13.1

LINE WIRE REFERENCE DATA

| Wire material | Diameter (mm) | Yield strength not less than (kg/mm$^2$) | Min. No of 180-deg. bends wire must sustain in vise with jaw radius of 10 mm | Min. hank weight (kg) | Wire used per km of new line (kg) |
|---|---|---|---|---|---|
| copper | 4 | 42 | 6.5 | 50 | 113 |
| | 3.5 | 42.5 | 8 | 48 | 86.5 |
| | 3 | 43 | 8.5 | 35 | 64 |
| bimetallic | 4 | 75 | 8 | 40 | 106 |
| | 3 | 75 | 8* | 25 | 59 |
| steel | 5 | 37 | - | 50 | 155 |
| | 4 | 37 | - | 40 | 100 |
| | 3 | 37 | - | 25 | 56 |
| steel-reinforced aluminum (stranded) | 5.4 | 120/17** | - | 50 | 70 |
| bronzed antenna wire (PAB) with cross-section of 25 mm$^2$ | 7.4 | 72 | - | - | - |
| bronzed antenna wire (PAB) with cross-section of 10 mm$^2$ | 4.6 | 75 | - | - | - |
| twisted steel cable | | | | | |
| 1x7-4.2-140-1 | 4.2 | 140 | - | - | - |
| 1x7-6.0-120-1 | 6.0 | 120 | - | - | - |
| 1x7-6.6-140-1 | 6.6 | 140 | - | - | - |
| 1x7-7.8-140-1 | 7.8 | 140 | - | - | - |
| 1x7-9-140-1 | 9.0 | 140 | - | - | - |

* Number of 180-degree bends in vise with jaw radius of 7.5 mm.

** Numerator indicates yield strength of steel strand and denominator indicates yield strength of aluminum strand.

TABLE 13.2

REFERENCE DATA FOR BINDING AND JOINTING WIRE

| Wire material | Di-ameter (mm) | Minimum yield strength (kg/mm$^2$) | Minimum No of 180-degree bends | Min. hank weight (kg) |
|---|---|---|---|---|
| soft copper (MM) | 2.5 | 21 | - | 25 |
| soft copper (MM) | 2.0 | 21 | - | 20 |
| soft copper (MM) | 1.5 | 21 | - | 20 |
| soft copper (MM) | 1.2 | 21 | - | 15 |
| soft cooper (MM) | 1.0 | 21 | - | 15 |
| galvanized steel | 2.5 | - | 13 | 20 |
| galvanized steel | 2.0 | - | 15 | 15 |
| galvanized steel | 1.4 | - | 17 | 10 |
| galvanized steel | 1.0 | - | 18 | 5 |

## 13.2 Insulators

Insulators are made of insulating materials which are dielectrically stable under varying weather conditions and have suitable mechanical strength and stability in the presence of sharp changes in temperature. Among such materials are porcelain and glass. However, the rated value of insulation of circuits may be maintained under all weather conditions only by the installation of high-grade insulators and by regular cleaning of their inner and outer surfaces.

Insulation of line conductors is achieved by the use of porcelain insulators of the TF (telephone, porcelain) type; in the case of conductor entrance equipment insulators of the VB (entrance, large) type and VM (entrance, small) type are used. Depending on the material and diameter of the conductors to be strung, use is made of the insulator types listed in Table 13.3.

TABLE 13.3

PRINCIPAL DIMENSIONS AND USES OF INSULATORS

| Insulator type | Use | Dimensions, mm height | diameter | inner diameter of thread | Weight kg |
|---|---|---|---|---|---|
| TF-2 | For steel conductors with diameter of 4-5 mm and for conductors of non-ferrous metals | 108 | 75 | 22 | 0.62 |
| TF-3 | For steel conductors with diameter of 3 mm | 86 | 61 | 20 | 0.35 |
| VB | For entrance equipment of conductors with diameter of 4 and 5 mm | 132 | 92 | 22 | 0.68 |
| VM | Same, for conductors with diameter of 3 mm | 103 | 70 | 18 | 0.35 |

## 13.3. Hooks, Crossarms, and Pins

Hooks are made of round steel and are distinguished by type: KN-20, KN-18, and KN-16. The letters KN signify "hook for low-voltage insulator," and the numeral indicates the diameter of the steel from which the hook is made. The uses of hooks and their principal dimensions are given in Table 13.4.

TABLE 13.4

PRINCIPAL DIMENSIONS AND USES OF HOOKS

| Hook type | Use | Dimensions, mm hook diameter | diameter of pin section | overall length of hook | Weight kg |
|---|---|---|---|---|---|
| KN-16 | For insulator types TF-3 and VM | 16 | 16 | 170 | 0.5 |
| KN-18 | For insulator types TF-2 and VB | 18 | 16 | 210 | 0.85 |
| KN-20 | Same, but on angle and terminal poles | 20 | 16 | 210 | 1.05 |

In the absence of a KN-20 hook for a corner pole two hooks of normal dimensions are used.

Crossarms serve to decrease the required length of poles in stringing a large number of conductors and also serve to obtain the required electrical characteristics in stringing more than two circuits of nonferrous metal. The principal materials used in making crossarms are wood and steel. The eight-pin and six-pin wooden crossarms (Figure 13.1) have found the widest use. Eight-pin crossarms are used for stringing of telephone conductors and six-pin crossarms are used for telegraph conductors. The types of wood used for crossarms are: oak, pine, larch, spruce, and cedar. For four-pin crossarms fir is also used. Crossarms are fastened to poles with bolts 16 mm in diameter and also with steel braces with dimensions of 5x25x610 mm. The braces are fastened to the cross-arms with bolts 10 mm in diameter and to the pole with lag screws 12 mm in diameter and 100 mm long.

Steel crossarms are made of equilateral angle iron with dimensions of 50x50x6 mm for lines of types O and N and with dimensions of 60x60x6 for lines of types U and OU.

Given the large loads which occur on corner, terminal, and other special poles, two crossarms are mounted. Double crossarms, both of wood and of steel, are mounted in the following cases:

on corner poles -- with a normal departure of angle of 7.5 m and more;

on sectional, cable, crossing, semi-anchor, terminal, and other special poles with a span 50 percent greater than normal;

on poles adjacent to entrance poles, on lines of types N, U, and OU.

Pins are used to fasten the insulators to crossarms. The uses and principal dimensions of pins are given in Table 13.5.

TABLE 13.5

PIN DIMENSIONS AND USES

| Type of pin | Use | Dimensions, mm: overall length | diameter of pin shank | diameter of pin head | Type of insulator | Pin weight kg |
|---|---|---|---|---|---|---|
| ShT-2D | For wooden crossarms | 245 | 16 | 16 | TF-2 | 0.46 |
| ShT-3D | For wooden crossarms | 225 | 16 | 15 | TF-3 | 0.38 |
| ShT-2S | For steel crossarms | 145 | 16 | 16 | TF-2 | 0.32 |
| ShT-3S | For steel crossarms | 125 | 16 | 15 | TF-3 | 0.29 |
| ShU-2D | For wooden crossarms of lengthened spans and corner poles on lines of types U and OU with departure of angle greater than 15 m and conductors with diameter of 5 mm | 250 | 22 | 16 | TF-2 | 0.8 |
| ShNK-2 | Same, for steel crossarms and for test straps and brackets | 160 | 22 | 16 | TF-2 | 0.51 |
| ShNS-2 | For L brackets and straps for transposition of conductors | 155 | 20 | 16 | TF-2 | 0.4 |

# CHAPTER 14. BASIC INFORMATION ON THE CONSTRUCTION OF OVERHEAD COMMUNICATIONS LINES

## 14.1. General Requirements -- Clearances

Communications lines must meet the following requirements:

They must pass along railroads, highways, paved roads, or dirt roads.

They must have the smallest possible number of crossings with other lines.

Poles must be located beyond ditches (gutters) or roads, within the limits of cleared side strips and chiefly at the edges thereof in order to allow for widening of the highway or railroad.

Wherever possible they must not run parallel to trolley and high-voltage lines, and they must not interfere with the movement of traffic, cross gardens, parks, plantings, sports areas, etc.

They must be removed from high-voltage transmission lines by the distance defined in Pravilami ograzhdeniya sooruzheniy svyazi i signalizatsii ot vrednogo deystviya ustanovok sil'nogo toka [Rules for Protecting Communications and Signalling Equipment Against Undesirable Effects from Heavy-Current Installations] (Svyaz'izdat, 1943) and Pravilami zashchiti ustroystv provodnoy svyazi ot meshayushchego deystviya kontaktnoy seti elektricheskikh zheleznykh dorog postoyannogo toka [Rules for Protecting Wire Communications Installations Against Interference from the Contact Systems of D-C Electric Railroads] (Transzheldorizdat, 1948).

They must be located not less than 0.5 km away from airfield perimeters; the erection of communications lines 0.5 to 1 km away from airfield perimeters must be carried out only after consent is obtained from those offices which are responsible for management of the airfields.

Poles must not be erected close to stands of trees (especially where there is danger of lines being broken by falling trees), nor in swampy areas or areas subject to flooding.

Wire mains must be strung above wires used for communications over a short distance.

The conductors over the extent of a repeater section must maintain the same spacing.

Stringing of conductors of intra-rayon communications (third-class lines) on first class lines is permitted with approval of the project in each case by the Ministry of Communications, and on second class lines, with the approval of the chief of the communications administration (oblast, kray, republic). Stringing of wire-rebroadcast conductors and city telephone conductors on first class and second class lines is not permitted.

In the construction and operation of overhead communications lines the established clearances (Table 14.1) must be strictly observed. In determining clearances it is necessary to consider the maximum sag of conductors which will result with the highest temperature for the given locality.

[See Table 14.1 Page No 71]

## 14.2. Laying Out Lines

Laying out of communications lines is performed from the beginning of a line to the first turn and between points with changes of direction which are the starting points for laying out lines. In laying out a line careful attention must be given to span lengths, especially for communications lines with composited circuits. In order to lay out a line it is necessary to have: a surveyor's chain for measuring spans, wooden stakes 3-4 m long, wooden pegs 30-40 cm long and with a diameter of 3-4 cm for marking pole locations, and a steel sapping spade.

Laying out of a line in straight sections is performed with three stakes in the following manner. At the beginning of the line or at a point of change in direction stake No 1 is placed. In the chosen direction place stake No 2 so that it can be seen from stake No 1. Next to stake No 1 drive pegs to indicate the location of the first pole.

TABLE 14.1

CLEARANCES OF SUPPORTS AND CONDUCTORS

| Type of clearance | Minimum clearance m |
|---|---|
| Distance from ground to lowest conductor on lines running along railroads outside populated localities | 2.5 |
| Same, on lines running along highways or dirt roads outside populated localities | 3.0 |
| Distance between the lowest conductor of one (upper) line and the highest conductor of another (lower) line at a crossing, with lowest and highest temperatures | 0.6 |
| Distance between the lowest point of the lowest conductor of a line and the peak of a roof | 1.5 |
| Distance between the lowest conductor of a line and the rail head in crossing a railroad with standard or narrow-gauge track | 7.5 |
| Distance from ground to lowest conductor of lines crossing highways, dirt roads, field (steppe) roads | 5.5 |
| Distance from ground to lowest conductor of lines on the periphery of a populated locality | 4.5 |
| Distance from highest ship mast at high flood to lowest conductor of line | 1.0 |
| Distance from line pole to nearest rail head with line running along railroad bed | 1 1/3 the height of the pole above ground |
| Distance from tree branches to conductors: | |
| in cities | 1.25 |
| in suburban areas | 2.0 |
| Distance from structures to poles with lines passing homes, booths, barracks, et al | 3.5 |
| Distance between poles close to one another: | |
| with steel circuits only, not less than | 8.5 |
| when one or both lines has nonferrous circuits composited with a 3-channel system, and also when one of the lines has a nonferrous circuit composited with a 12-channel system | 8.5 |
| when both lines have nonferrous circuits composited with a 12-channel system | 20 |

From stake No 1 mark off the distance of a span with the surveyor's chain. The precise location of the second pole is established by placing stake No 3 in line with stakes No 1 and 2. For this purpose stake No 3 is moved to the right or left until, as viewed from stake No 1, it blocks out stake No 2. The location of the second pole is marked by a peg on which the pole number is written.

Subsequent pole locations are determined in the same manner.

In crossing from a pole of normal height to higher poles it is necessary to use crossing poles of various heights according to the data of Table 14.2.

TABLE 14.2

HEIGHT OF CROSSING POLES

| Height of base pole, m | Height of tallest pole, m | Dimensions of intermediate crossing poles, m |
|---|---|---|
| 6.5 | 11 | 8.5 |
| 6.5 | 13 | 8.5, 10 |
| 6.5 | 15 | 8.5, 11 |
| 6.5 | 19 | 8.5, 11, 15 |
| 7.5 | 11 | 8.5 |
| 7.5 | 13 or 15 | 9.5, 11 |
| 7.5 | 17 or 19 | 9.5, 11, 15 |
| 8.5 | 13 | 10 |
| 8.5 | 15 or 17 | 11, 13 |
| 8.5 | 19 | 11, 13, 15 |

Spans adjacent to corner poles must be of normal length with the exception of lines of types U and OU on which, with six conductors or more and with the normal departure of angle greater than 7.5 m, the length of the adjacent spans must be half the normal length. Poles adjacent to corner poles are reinforced with braces parallel to the line from the corner pole with the departure of angle 7.5 m and more and with the following number of strung conductors: on lines of types O and N, 24 and more; on lines of types U and OU, 12 and more.

On steep grades when adjacent poles are located one higher than the other by 0.2 a span length or more, poles carrying 16 conductors and more are reinforced by extended guys in the uphill direction or by braces from the downhill side. With up to five poles on the slope only the pole at the top of the hill is reinforced. With a large number of poles every fifth pole is reinforced and two poles at the top of the hill.

## 14.3. Digging Holes, Rigging and Setting Poles

In the construction of overhead communications lines over a wide area the greatest productivity of labor in digging holes and setting poles may be achieved by performing these operations with the use of a combination derrick and pole-hole digger of the type BKGM-AN mounted on a GAZ-67 truck. This assembly permits digging holes up to 1.5 m deep and with a diameter of 0.35-0.5 m. The time directly consumed in digging a single hole in soft or firm ground ranges from 40 seconds to one minute. In ground frozen to a depth of 0.6-0.8 m the digging requires 2-2.5 minutes.

The personnel working with the digging machine consists of a driver and a digger. With this assembly 120 poles may be set within an eight-hour workday.

Holes may also be dug manually by means of a special hole digger. The hole digger designed by V. M. Nefedov consists of two shovels a (Figure 14.1) attached to wooden handles b and joined by a hinge c. The shovels are made of No 5 sheet steel 2 mm thick. The handles for the digger are usually made from the butt-end section of a straight-grained birch.

The hinge permits separation of the shovels (before clamping the soil) or closure of the two with the soil caught between them.

In swampy ground a hole is easily dug with one of these hole diggers and without any additional instruments. In digging a hole in soft ground it is necessary to have an ordinary spade in addition to the hole digger, and for digging in hard ground a chopping blade (Figure 14.2) is also necessary to loosen the soil.

Digging of holes in soft ground with the hole digger begins with use of the spade for removal of a circle of soil 350 mm in diameter from around the peg marking the pole location. According to the ease with which soil may be removed with the spade, the hole is dug to a depth of approximately 0.5 m.

For further digging of the hole with the special hole digger the soil must first be loosened with the chopping blade. The hole digger is then opened to the diameter of the hole and is thrust into the ground. By changing hands on the handles of the hole digger the worker draws the shovels together, clamping the soil between them. With the shovels held in this position, the hole digger is removed with the clamped soil from the hole. Opening the hole digger, the worker places the soil around the hole.

The instrument must be kept clean and the cutting edges of the shovels must be unriveted and sharpened. This considerably lightens the work and increases the productivity of labor. In small-scale operations holes are dug manually in the form shown in Figure 14.3. For poles adjacent to corner poles or terminal poles the holes are dug so that the widened part is in the direction of the corner pole or terminal pole. Holes for guyed corner poles are dug with the widened part on the side opposite the pull of the conductors; holes for braced corner poles are dug with the widened part in the direction of the conductor pull.

In digging holes in populated localities it is necessary to place a barrier and warning signs around the hole and at night lighted lanterns must be hung from the barrier.

In digging a hole the soil must be thrown back at least 0.4 m away from the hole. Rocks encountered in digging must be thrown beyond the removed soil in order to prevent them from rolling back into the hole and injuring the worker.

Rigging of a wooden pole consists in trimming off the remains of outer and inner bark, roofing the pole, marking off and boring the holes for hooks and crossarm bolts, screwing in the hooks, fitting insulators on them, preparing crossarms, mounting them and placing brackets or straps at transposition points for telephone circuits.

The top of the pole is roofed as shown in Figure 13.1. Poles with a single-side bend are roofed so that the bend of the pole is in the direction of the line. All poles should be erected so that the ridge of the roof is parallel to the line.

If a pole is equipped with hooks and it is not anticipated that crossarm suspension will be employed at a later date, the ridge of the roof must be perpendicular to the direction of the line.

Holes for hooks are bored on both sides of the pole: on lines of types O and N these holes will be 40 cm apart, and on lines of types U and OU they will be 60 cm apart. The distance from the first hook to the top of the pole should be 15 cm. The distance between crossarm gains should be 60 cm.

The depth of holes for screwing of hooks should be 1 cm less than the threading of the hook. Hooks are first screwed into the pole by hand and then by wrench so that the distance between the hook and the pole is 2 cm. On corner poles and on all poles on lines of types U and OU the hooks are screwed close up to the pole. Twin hooks are arranged as shown in Figure 14.4.

Crossarms are mounted on poles before they are erected. Crossarms must be parallel to one another and perpendicular to the pole axis. On poles on slopes of 20 degrees and greater the bolt holes and gains are made at an angle to the pole axis equal to the angle of ascent of the line.

On corner poles with a normal departure of angle of 5 to 7.5 m and with a span exceeding the normal by 20 to 50 percent as well as on pilot poles, single crossarms are mounted and reinforced with four braces.

Double wooden or steel crossarms are mounted on single poles in the following cases:

on corner poles -- with a normal departure of angle of 7.5 m or more;

on poles adjacent to entrance poles -- on lines of types N, U, and OU;

on poles with spans exceeding the normal by more than 50 percent;

on poles crossing railroads, paved roads, and highways;

on entrance poles;

on cable poles and other special supports.

On centrifugated reinforced-concrete poles only crossarms are mounted. The top of the pole is covered with a cap.

Insulators are screwed onto hooks and pins at the work place before erecting the pole. The untwisted end of a cable filler is applied to the upper notched portion of the hook (or pin) and is wrapped closely around for the length of the insulator threading. The cable filler is wound in the clockwise direction from bottom to top and then from top to bottom. The thickness of the layer of cable filler must be such that the insulator is screwed on with great effort. After winding the cable filler the end is also untwisted and several turns are wound around the upper part of the hook (or pin). The insulator is screwed onto the hook (or pin) to the limit by turning it with both hands and at the same time pressing down. When in position the top groove of the insulator must be in line with the conductor. The insulator must not be turned in the reverse direction.

Poles are erected by means of the combination derrick and pole-hole digger or by means of a winch. In erecting a wooden pole by hand it is set from the stepped side of the hole so that the butt extends over the hole and is no closer than 30-40 cm to the rear side of the hole. While the pole is being raised a worker

holds a bump board against this side of the hole. He guides the butt end of the pole by striking it with a ram. The workers raise the pole from the top and push it till it rests against the bump board. When the pole is at the point where it can no longer be raised with bare hands, one of the workers supports the tip of the pole with a jenny and the others, moving gradually toward the center of the pole, continue to raise it with jennies and pike poles. With a pole length of 8.5 m or more it is necessary to use 3-4 jennies or pike poles.

The use of shovels, axes, and other incidental equipment in the manual erection of a pole is not allowed. The workers must not place the ends of grabs or pike poles against the chest. In raising the pole the workers must not stand under it.

As long as there is a worker in the hole the butt of the pole must not be moved for alighment or facing of the pole.

The erection site of a pole in a populated locality must be guarded and bystanders must not be permitted in the immediate area.

When the pole has been raised the bump board is removed from the hole and the pole is set in line with the previously erected poles. If the foot of the pole is not in a straight line, it is moved to one side of the hole by using a tamping bar as a lever. The pole must be set plumb.

After the pole has been lined up it is faced; that is, the pole is turned so that the hooks or crossarms are perpendicular to the direction of the line. The dirt removed from the hole is replaced in layers of 15-20 cm and firmly packed by mechanical or manual tamping. The excess dirt is placed around the pole in the form of a conical rise and then tamped.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

In erecting poles with crossarms the crossarms must be placed:

on straight sections of line -- alternately on one side and the other;

on a corner pole -- on the side of the shorter span; with adjacent spans of identical length -- on the side with the shorter section of straight line to the next bend in the line; on the two poles adjacent to a corner pole -- on the side facing the corner pole;

at road crossings -- facing the crossing;

on upgrades -- facing upgrade.

A corner pole should be given a tilt against the resultant direction of conductor pull so that after stringing the conductors the top of the pole will coincide with the vertex of the vector angle. For this purpose the butt of the pole is set within the angle at a distance of 25-35 cm from the vertex of the angle.

In those cases where the pole must be protected against damage by vehicular traffic a guard stub is installed (Figure 14.5). Within the limits of populated areas the poles are protected by rails, girders, etc driven into the ground next to the pole.

## 14.4. Stringing Conductors

Before the wire is strung it is unreeled along the line. The reel is placed on a truck or wagon. The wire must be unreeled with care, for kinks (tightened loops) may result from irregular movement of the reel due to excessively free unreeling or one or several turns slipping from the reel. Pieces of wire having partial breaks, cracks, flats, or kinks must be cut out. The hank of wire is wound on a reel and its free end is fastened to the pole from which the stringing begins.

In unreeling wire of nonferrous metal its bast or paper sealing must not be removed before arriving at the stringing location. If the wire is received at the stringing site without such sealing, it must be subjected to careful examination. The wire must not be strung if faults are detected; a report is prepared and the wire is returned to storage. Hanks of nonferrous wire must not be dumped to the ground.

Steel conductors are stretched out before being strung. For this purpose one end of the wire is clamped in a pulley grip fastened to the base of a pole by a loop or strap. The other end of the wire is also held in a grip at a distance of 6-8 spans from the first pole. The wire is then stretched out with pulleys. In stretching 4- and 5-mm conductors two workers are required to draw the pulley ropes, and in stretching 3-mm conductors one worker is required. The wire must not be stretched after it has been placed on the insulators. Nonferrous conductors are not stretched.

In stretching conductors in a populated locality or across roads it is necessary to post watchmen to keep pedestrians and motorists away.

The ends of copper and bimetallic conductors are joined by means of copper sleeves (Figure 14.6) and the ends of steel conductors are joined by electric welding or thermite welding.

The procedure in joining conductors by electric welding is as follows. The ends of the conductors are trimmed with a file. The welder then places welding clamps over the ends of the conductors so that the ends extend from the clamps by an amount equal to the diameter of the conductor. Holding the clamp handle with both hands, the welder orders the welding assembly to be lowered

into place. When the necessary voltage has been established the welder depresses a knob on the clamp handle. This brings the ends of the conductors together and they quickly begin to glow. When welding heat has been reached (which is evident from the white incandescence and fine sparkling), with a quick movement of the handles the welder closes the clamps and releases the knob. The resulting joint should be a strong metal bond with a smooth, uncracked boss in the form of a ring with an evenly welded surface. Jagged projections on the ring indicate that the conductor has been overheated. Pitting of the ring indicates underheating. Such joints are unsatisfactory and should be rewelded.

Thermite welding of steel line conductors is performed by means of a thermite cartridge ignited by a thermite fuse. A welding vise is used in thermite welding. The conductors are held in the vise with their ends approximately midway between the clamps and aligned so that one conductor appears at the continuation of the other. The clamps are set at the limit position. The thermite is slipped over the end of one of the conductors. The vise is closed until the ends of the conductors are in contact and the cartridge is shifted so that its center coincides with the junction of the conductors. If it is difficult to move the cartridge along the conductor, then it is necessary to remove from around the joint the thermite powder which usually forms in this case and to replace the cartridge. Donning protective goggles, the welder ignites the fuse. When the flame reaches the edge of the crater the thermite is fired. The cartridge burns out in 6-7 seconds. The ends of the conductors do not reach full heat until a certain time after the cartridge is burned out. When the ends of the conductors are sufficiently heated (that is, after



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

the cartridge has burned out and the metal begins to soften) the welder slowly brings the clamps of the vise together, gradually increasing the compression. When the burned out cartridge is cooled to darkness it is struck off and the conductor is cleared of the cartridge residue.

After welding, the conductor is given a 20-cm covering of bitumen (that is, 10 cm on both sides of the joint).

The reliability of the joint is tested by sudden slackening of the pulleys. With a poor weld the conductor will break at the joint. In joining conductors on the ground the reliability of the joint is checked by pulling the conductors. If the conductor breaks and products of thermite combustion are seen in the break, it will indicate that the ends of the conductors were not firmly joined and, in putting the thermite cartridge on, thermite powder fell between them. If pitted areas and blisters are seen in the break, it will indicate that the jaws of the vise were not sufficiently closed during welding. When one conductor does not appear as the continuation of the other the site of the incorrect weld must be cut out and the weld repeated. Such welds usually occur due to incorrect placement of the conductors in the clamps or due to premature closing of the clamps (before heating of the conductors to the welding temperature). In welding conductors of different diameter (for example, 4 and 5 mm) a large cartridge is used.

The welder must wear dark goggles during thermite welding. The face of the welder must not come closer than 0.5 m to the welding site.

The burned out cartridge must be struck off away from the welder after it has cooled. The thermite fuse must be allowed to fall only on previously examined ground where there is no combustible material.

The thermite cartridges must be kept in a metal box in the worker's pouch apart from the thermite fuses and other objects.

In stringing the conductors they are fastened to the first pole in a dead-end tie (Figure 14.7). Copper and bimetallic conductors are fastened to the therminal insulators by means of sleeving. Each conductor is reeled out and hoisted by means of a hand line (a rope with a hook). On intermediate poles they are placed in the top grooves of the insulators and on corner poles they are placed in the side grooves. Lifting conductors onto the poles on the shoulders is not permitted. Nor is it permissible to lay the conductors, especially if they are nonferrous, on hooks and steel crossarms. The conductors are hoisted over 6-8 spans and, by means of pulleys fastened with a wire loop to the base of one of the adjacent poles, they are pulled up to the required sag.

All work on a pole must be performed with the climbers firmly fastened to the legs and with a safety strap with snap hooks. It is not permissible to climb a corner pole and work from the inner side of the angle. To work with all the weight on one climber and with the other leg resting against the pole or a brace is not permitted.

Conductors are adjusted for the required sag in the following manner:

Next to the insulators on one of the spans in the middle of the line section to be adjusted two sagging T's (Figure 14.8) are hung from the conductors.

The crosspieces of both T's are set at a value corresponding to the sag for the given span as found from Table 14.3. The crosspieces are fastened in this position by means of wing nuts. The sag is determined from the table according to the air temperature (air temperature is measured with the thermometer in the shade). The worker on one of the poles sights across the upper edge of the crosspiece of his T to the crosspiece of the other T and given the instructions to draw up or lower the conductor until the lowest point of the span of wire is in a line with the upper edges of the sagging T's.

The sag of a conductor may also be determined from its vibration. For this purpose the conductor is started vibrating in the horizontal plane by striking it with a rod from the ground or by hand from a pole and counting the number of wave trips. At the moment the wave is at one of the extreme positions start a stop watch or note the position of the second hand on an ordinary watch. A complete vibration of the conductor consists of the wave's travel from the point at which timing was begun until its return to this initial position. At the thirtieth return wave stop the stop watch or note the position of the second hand on the watch and determine the time required for thirty complete vibrations. Divide the number of return waves (30) into the number of seconds and multiply the result by sixty, giving the number of return waves per minute. The conductor sag is then determined from Table 14.4.

TABLE 14.3

INSTALLED SAG OF COPPER, BIMETAL, AND STEEL

CONDUCTORS WITH DIAMETER OF 3-5 MM

| Temperature in °C | Span in m: 35.7 | 40 | 50 | 62.5 | 80 | 100 | 120 | 150 |
|---|---|---|---|---|---|---|---|---|
| | Sag in cm | | | | | | | |
| - 30 | 8.5 | 11.5 | 17.5 | 20 | 57 | 92 | 139 | 207 |
| - 20 | 10.0 | 13.5 | 20.0 | 33 | 67 | 104 | 153 | 234 |
| - 10 | 12.0 | 15.5 | 23.5 | 39 | 77 | 116 | 169 | 261 |
| 0 | 14.5 | 19.0 | 28.0 | 46 | 87 | 129 | 186 | 290 |
| + 10 | 17.5 | 23.0 | 33.5 | 55 | 98 | 141 | 203 | 317 |
| + 20 | 22.0 | 29.0 | 41.0 | 65 | 109 | 151 | 222 | 317 |
| + 30 | 27.5 | 36.0 | 49.0 | 76 | 120 | 166 | 238 | 374 |

TABLE 14.4

SAG AS A FUNCTION OF THE NUMBER OF RETURN WAVES

| No of return waves per min. | Conductor sag, cm | No of return waves per min. | Conductor sag, cm |
|---|---|---|---|
| 25 | 176 | 50 | 44 |
| 30 | 122 | 53 | 39 |
| 35 | 90 | 55 | 36 |
| 40 | 69 | 60 | 31 |
| 45 | 54 | 70 | 22 |

In stringing nonferrous conductors use should be made of pulleys with parallel-jaw grips. Pliers and clamps must have copper inserts.

Prior to stringing steel-reinforced, stranded aluminum conductors it must be remembered that the wire must be kept in coils and on planks, and in no case should it be left on the ground without wrapping, since the wire may rust. Moreover, the wire must not be dragged over the ground during stringing operations, for the aluminum strands may be damaged and the conductor will be unfit for use.

Before stringing steel-reinforced aluminum conductor it must be pulled in the same manner as the steel conductor. The force applied in the pulling operation is checked by means of a dynamometer located between the grip and the pulleys; this force should be equal to 150 kg. In pulling steel-reinforced aluminum conductors a special wooden grip, shown in Figure 14.9, is used. The sag is set according to the data in Table 14.5. The conductors must not be overstressed; that is, the sag must not be less than that called for in Table 14.5

TABLE 14.5

SAGS FOR STEEL-REINFORCED ALUMINUM CONDUCTOR AT DIFFERENT TEMPERATURES

| Temperature in °C | Span in m: 30.7 | 40 | 41.67 | 50 | 62.5 |
|---|---|---|---|---|---|
| | Sag in cm | | | | |
| - 30 | 7 | 9 | 9 | 13 | 22 |
| - 20 | 8 | 11 | 11 | 16 | 27 |
| - 10 | 10 | 13 | 15 | 20 | 34 |
| 0 | 13 | 18 | 20 | 27 | 44 |
| + 10 | 19 | 25 | 27 | 35 | 56 |
| + 20 | 27 | 34 | 37 | 46 | 69 |
| + 30 | 36 | 44 | 47 | 58 | 83 |

## 14.5. Fastening Conductors to Insulators and Numbering Poles

Conductors are fastened to insulators with binding wire (Table 14.6). The fastening must be secure so that the conductors do not cross from one span to another and do not break away from the insulators. On straight sections of line the conductors are tied with two pieces of binding wire -- 50 cm long for TF-2 insulators and 46 cm long for TF-3 insulators (Figure 14.10). Each piece is wrapped around the neck of the insulator and twisted up to the top groove. One end of each of the wires is made longer than the other by an amount equal to the length of the groove. The long ends of the binding wire are brought to the opposite sides of the insulator across the line conductor and bent downward. Together with the short ends these are firmly wrapped around the line conductor with the use of pliers.

TABLE 14.6

MATERIAL AND DIAMETER OF BINDING WIRE FOR DIFFERENT TYPES OF LINE CONDUCTOR

| Line conductor: Material | Line conductor: Diameter, mm | Binding wire: Material | Binding wire: Diameter, mm |
|---|---|---|---|
| Bimetal | 4 | Soft (MM) of bimetal copper | 2.5 |
| Bimetal | 3 | Same | 2 |
| Copper | 3.5, 4 | Same | 2.5 |
| Copper | 3 | Same | 2 |
| Steel | 5, 4 | Zinc-clad steel | 2.5 |
| Steel | 3 | Same | 2 |
| Steel-reinforced aluminum | 5.4 | Aluminum | 3 |

On corner poles the conductor is fastened to the neck of the insulator from the outer side of the angle with two pieces of wire of the same length as in the previously mentioned case. Both pieces of wire are placed together and laid crosswise over the conductor. Then they are bent around the neck of the insulator in opposite directions and are firmly wrapped around the conductor from both sides of the insulator by means of pliers (Figure 14.11).

In tying conductors to insulators on intermediate and corner poles it is recommended that the device proposed by A. V. Ivanov be used. This device (Figure 14.12) consists of a wooden block with a groove and two holes into which are inserted pegs of steel wire with a diameter of 4 mm. To one side of the block there is fastened a steel plate on which there are four projections (brads), and to the other side there is fastened a plate with the edge bent out.

When the usual method of tying has proceeded to the point where the tie wire is to be wrapped around the line conductor, the groove of the tying device is placed over the line conductor so that the four brads are on the side facing the insulator and are fastened by the peg. Then the ends of the tie wire are inserted into the space between the brads and the device is turned on the conductor in the clockwise direction until the ends of the tie wire will no longer twist around the line conductor. In the same manner the other two ends of tie wire are wrapped around the conductor on the other side of the insulator.

The single bent edge of the plate on the other side of the device is designed for undoing a tie when it is to be replaced.

In this case the device is placed over the conductor with this projecting edge facing the insulator, the ends of the tie wire are engaged behind the projection, and the device is turned around the conductor until all the turns of the tie wire are untwisted.

Due to the action of wind the conductors strung on the line are in constant vibration. Two forms of conductor vibration are observed: horizontal vibration, which, in the presence of a strong breeze, causes whipping of conductors located on cross-arms, and vertical vibration of conductors (known as conductor vibration), which is caused by pressure of eddy currents of air set up on the leeward side of the conductor. The vibration increases the stress in the line conductor and binding wire and causes metal fatigue, leading to conductor failure.

In addition to the above conductor vibrations (that is, small-amplitude vibration), there is sometimes observed on communications lines conductor vibration in the vertical plane with an amplitude equal to the sag of the conductor. This phenomenon is known as conductor "dancing." The cause of dancing has not been subjected to sufficient study. For the elimination of contacting and whipping of conductors it is necessary to hang conductor-whip eliminating (USP) insulators in the middle of the span, as proposed by G. M. Lykhin and M. A. Klimov. The USP insulators are fastened to copper and bimetallic conductors by means of copper binding wire with a diameter of 2 mm and copper-foil backing; the insulators are fastened to steel conductors by means of steel wire (Figure 14.13). Strips of wood join the insulators in the horizontal plane.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

The service life of conductors on communications lines subject to vibration may be prolonged by the use of spring ties (Figure 14.14). The chief difference between the spring tie and the ordinary tie is that against the line conductor and from both sides of the insulator there is placed a section of wire (spring) of the same diameter and material as the line conductor. Steel wire with a diameter of 2.5-3 mm is used for spring ties on steel conductors, and for copper and bimetal conductors annealed wire of the same material and diameter as the line conductor is used. The conductor and the end of the spring are bound with tie wire.

In order to facilitate making the "special tie" (spring tie), V. N. Speranskiy has proposed the use of a wrench instead of the pliers.

The wrench is made of rod steel 200 mm long and 12 mm in diameter (or of strip steel 14x5 mm). In making the wrench of rod steel 55 mm of one end are flattened to the dimensions 14x5 mm. The remaining 145 mm serve as the wrench handle. In making the wrench of strip material wooden grip pieces are riveted onto the handle section. In the flat portion of the wrench two 4.5-mm holes and two 3.5-mm holes are drilled at intervals of 10 mm as shown in Figure 14.15. The holes are slightly countersunk with a larger drill and the burrs are removed.

Before using the wrench, the tie wire is pressed against the neck of the insulator and both ends of the wire are inserted into the holes of corresponding diameter in the wrench. The wrench is advanced as close as possible to the insulator and, by turning it, both ends of the tie are twisted over the required length. The wrench is removed and the ends of the tie are placed

on either side of the insulator, one of them directed upwards and the other along the spring wire and the line conductor. Then the end of the wire which begins the tie is inserted in one of the holes of the wrench and is wrapped around the line conductor and the spring wire until the end of the tie wire slips out of the wrench hole.

The other end of the tie is twisted in the same manner but in the opposite direction. This procedure is repeated on the other side of the insulator.

In using the wrench considerably less force is required than when using pliers and the tie is made more quickly and accurately due to the fact that the edge of the wrench rides over the previously applied turn. Use of the wrench also decreases the likelihood of damaging the conductor.

All poles between terminal or amplifier points are numbered. Numbering begins with the entrance or cable pole from the larger administrative center. Where the line joins two points of equal importance, numbering proceeds from north to south and from west to east. Loops are numbered independently beginning with the section pole. The number must face the road. The numbers are applied to the poles with black oil paint on a yellow or white background (Figure 14.16) with the use of a stencil. The pole surface on which the numbers are to be applied is first cleaned. Then, the last two numbers of the year in which the pole was erected are applied and the sequence number of the pole is given in with the digits in vertical order. On poles joining transposition sections the letter C is added. When a section has more

than a thousand poles, the digit indicating each thousand is applied only to those poles on which the number ends in zero and on the other poles this space is left unoccupied. The distance from the ground to the top of the year number is two meters.

In erecting auxiliary poles it is not necessary to renumber the poles, but simply to give the number of the previous pole with the addition of a slant bar and the sequence number of the additional poles. For example, in the extension of a spur line from pole 1234 to 1284 it is necessary to erect 54 poles instead of 50. In this case next to pole 1235 number 1234/1 is placed and the following additional poles are numbered 1234/2, 1234/3, 1234/4. The other poles retain their numbering of 1235, 1236, 1237, etc.

With a decrease in the number of poles on a line section (upon installing a cable insert or straightening a line) the numbers of the eliminated poles are removed from the numbering and the remaining poles retain their old numbering.

## 14.6. Overhead Crossings

Wire crossings of communications lines and the conductors of contact systems of electrified roads, highways, railroads, etc are made according to technical specifications and standards. Wire-crossing spans differ from ordinary spans in that the mechanical strength of the former is increased by braces or semi-anchor poles and, instead of single conductors, cables are employed with double insulator fastening. The principal technical requirements for poles and conductors at cross-over spans are given in Table 14.7.

Intra-rayon communications lines, city telephone networks and wire broadcast networks with voltages not in excess of 60 volts are placed in cross-over spans below the conductors of inter-city communications lines.

TABLE 14.7. ORGANIZATION OF OVERHEAD CROSSINGS OF COMMUNICATION LINES

| [1] Nature of installation to be crossed | [2] Angle of crossing | [3] Type of pole at crossing | [4] Communications conductors | [5] Type of fastening of communications conductors | [6] Length of crossing span | [7] Additional requirements for organization of crossing |
|---|---|---|---|---|---|---|
| Railroads of standard and narrow gauge. | 90°, but not less than 45°. | Up to 16 conductors -- intermediate, reinforced with braces; more than 16 conductors -- semi-anchor. Braces placed on railroad side. Lightning arresters installed on poles. | Of the same material and diameter (for steel conductors, not less than 4 mm) as the line conductors. | On double hooks or double crossarms (Figure 14.17 and 14.18). | On lines of type O not more than 80 m, type N not more than 60 m, and types U and OU not more than 35 m. | With more than 32 conductors on lines of types O and N and more than 24 on lines of types U and OU, cable sections are installed. Joining of conductors within a crossing span not permitted. |
| Contact system of electric railroad. | Same | Same | On lines of types O, N, and U -- bronzed wire of type PBI-10; On lines of type OU -- PAB-25 or bimetal cable with cross-section of 25 mm2, or insulated wire covered with weatherproof insulation, the breakdown voltage of which must be at least twice the working voltage of the contact wires to be crossed. | On double crossarms (Figure 14.19). | On lines of type O not more than 100 m, type N 75 m, type U 60 m, and type OU 40 m. | On city telephone lines with more than 10 conductors cable is laid. |



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

[Table 14.7 continued]

| | | | | | | |
|---|---|---|---|---|---|---|
| Contract trolley or trolley-bus conductors. | Same | Same | Bimetallic with diameter of 4 mm, bronzed antenna wire (PAP) with cross-section of 10 $mm^2$, bimetallic cable with cross-section of 10 $mm^2$, or insulated conductor covered with weatherproof insulation, the breakdown voltage of which must be at least twice the working voltage of the contact wires to be crossed. | On double crossarms (Figure 14.19). | Same | Same |
| Principal highways and roads. | 90°, but not less than 45°. | Intermediate, reinforced with braces on the road side. Lightning arresters installed on poles. | Of the same material and diameter as the line conductors. | On double hooks or double crossarms (Figure 14.17 and 14.18). | Normal for the given type of line. | Joining of conductors within a crossing span not permitted. |
| Dirt roads. | Not prescribed. | Intermediate. | Of the same material and diameter as the line conductors. | Single intermediate tie. | Same | |
| Power transmission lines with voltage higher than 1 kv. | 90°, but not less than 45°. | Intermediate. At voltages greater than 6 kv the crossing poles are reinforced with braces in the direction of the line. Lightning arresters installed on poles. | Same. Conductors pass beneath power transmission lines. | On double hooks or double crossarms (Figure 14.17 and 14.18). | Same | Distance from cross-over point to nearest power transmission pole must not be less than 7 m. Joining of conductors within a crossing span not permitted. |

[Table 14.7 continued]

| | | | | | | |
|---|---|---|---|---|---|---|
| Power transmission lines with voltage up to 1 kv. | 90°-45°. | Intermediate. | Of the same material and diameter as the line conductors. | Single intermediate tie. | Same | Same |
| Rivers, gullies, and other obstacles. | Not prescribed. Navigable rivers 90°, but not less than 45°. | Up to 16 conductors -- intermediate, reinforced with braces; more than 16 conductors -- semi-anchor. Braces placed on crossing side. | Same | On double hooks or double crossarms (Figure 14.17 and 14.18) with span exceeding normal by more than 50 percent. | On lines of type O not more than 150 m, type N 100 m, type U 50 m, and type OU 35 m. | Joining of conductors within a crossing span not permitted. With longer spans steel cable 1x7-4.2-140 and bimetallic cable with cross-section of 25 $mm^2$ (Figure 14.19). |
| Communications lines of second and third class of city telephone nets and radio broadcast nets to cross first class communications lines. | 90°, but not less than 45°. | Intermediate, reinforced with braces on the side of first class line. | Of the same material and diameter as the line conductors, but not less than 3 mm on lines of types O and N and not less than 4 mm on lines of types U and OU. Conductors pass over the conductors of the first class lines. | On double hooks or double crossarms (Figure 14.17 and 14.18). | On lines of type O not more than 80, type N 60 m, and types U and OU 35 m. | In passing second and third class lines, lines of radiofication and city telephone nets beneath first class communications lines braces are not installed and conductors are not double fastened. |

## 14.7. Installation of Lightning Arresters

Dangerous voltages may appear on overhead conductors during a storm owing to lightning surges directly at line installations or owing to induction during the discharge from a cloud to ground. The voltage induced in the conductors sometimes reaches several tens of thousands of volts and may easily puncture the insulation of cables and conductors. Direct surges of lightning in a conductor cause fusion of conductors and direct strokes may split poles. The wood of the pole is split due to the suddenly increasing pressure of vaporizing moisture with the passage of lightning currents.

In order to protect supports against lightning damage line lightning arresters are installed on entrance, cable, sectional, test, semi-anchor, corner, crossing, and tower supports. Moreover, all supports erected as replacements for those damaged by lightning are also equipped with lightning arresters regardless of the presence of lightning arresters on adjacent supports.

The lightning arrester is installed in the following manner. Steel wire with a diameter of 4 or 5 mm is placed flat against the length of the pole and fastened with staples of the same material at every 30 cm. The lower end of the wire is covered in a trench at a depth of 70 cm and running from the pole to a length given in Table 14.8

At corner and intermediate poles the lower end of the lightning-arrester wire is not led off to the side but is brought to the base of the pole, and, after stapling, is cut.

TABLE 14.8

LENGTH OF WIRE FOR GROUNDING OF LIGHTNING ARRESTER

| Nature of ground | At entrance, cable, test, sectional, and crossing poles (meters) | At poles at cross-over spans with transmission lines (meters) |
|---|---|---|
| Swamp | 1 | 2 |
| Chernozem | 1 | 3 |
| Clay | 1.5 | 4 |
| Loam | 2 | 5 |
| Sandy loam | 5 | 9 |
| Wet sand | 6 | 15 |
| Sand of average dampness | 7 | 25 |
| Stoney | 8 | - |

The wire is run along the side of the pole not occupied by hooks or crossarms. The lightning arrester should extend 5 cm above the top of the pole or reach the roof of the pole (existing arresters). On poles with communications lines crossing power transmission lines a 5-cm break (air gap) is made in the arrester wire 30 cm above the ground. The break is made for the purpose of protecting line personnel on the pole in case of a random voltage increase on the conductors to the dangerous level. Lightning arresters are not placed on reinforced-concrete poles.

## 14.8. Conductor Entrances at Station Structures

With the number of conductors not greater than 16 a single pole reinforced by bracing or guying serves as an entrance pole. With a greater number of conductors the entrance pole is a semi-anchor pole or double pole reinforced by bracing or guying. On lines of types U and OU a pole next to an entrance pole with more than 10 conductors is reinforced with a brace. The entrance pole is erected not more than 15 m and not less than 2 m from the building.

Entrance brackets are made of angle iron. In providing an overhead entrance for circuits composited in the frequency band up to 60 kc the entrance brackets (inlet and outlet) must be placed so that the distance of the ends of crossarms is not less than 2 m. The line conductor at the entrance insulator is terminated in a dead-end tie, hence the conductor is not drawn up as tightly as in ordinary spans.

SRG [lead-sheathed] cable, a special weatherproofed shielded conductor, or PR [rubber-insulated] conductor is joined to the line conductor in the following manner. The cable (trimmed of lead sheathing or shield) is inserted through the channel of the entrance insulator (Figure 14.20) and bent so that the lead sheath or shield does not come within 3-4 mm of the base of the cap. In using PR conductor the fiber braid and rubber insulation are stripped back so that the braid does not come within 1 cm of the end of the insulation.

Near the second rim of the cap the cable or PR conductor is stripped of insulation and the bare wire is brought out through the hole. Three or four turns are wrapped around the conductor and then around the stripped line tap; these are soldered. The PR conductor is inserted into the cap of the insulator so that the end of the insulation is located in the middle of the cap.

The open space in the head of the insulator (the cap) is filled with melted MT-2 insulating compound. Passing from the insulator without touching the skirt, the cable or conductor is led beneath the crossarm and directly to the lead-in funnel.

In using TF insulators for the entrance the SRG cable is fastened in the following manner. The cable is brought along the

crossarm to the insulator and is turned down and the lead sheathing removed. Insulating tape is wrapped around the cable at the point of bend and is covered with asphalt lacquer. Then the end of the cable, covered with rubber insulation, is bent up, passed into the loop of the line conductor, wrapped around the stripped line tap, and soldered.

In using PR conductor the wire is stripped of insulation and the fiber braid is removed 2 cm beyond the rubber insulation. The end of the braid is secured with five turns of thread. The end of the insulation and the fiber braid are then covered with asphalt lacquer.

The trimmed end of the conductor is given one wrap around the neck of the insulator so that the rubber insulation is 1 cm away from the neck. The end is then given two turns around the conductor and brought over the top groove of the insulator, after which it is passed into the loop of the line conductor, given 3-4 wraps around the joint seal of the latter, twisted onto the stripped line tap and soldered.

For the entrance of circuit conductors composited in the frequency range up to 150 kc and also for circuits composited up to 30 kc a cable pole is erected and equipped with damping coils and autotransformers or loading coils.

The damping coils are used to increase the transmission loss across the third circuit between the input and output of amplifiers in composited circuits. A damping coil has two windings, each of which is connected to one of the conductors of the circuit. The coil offers a high impedance to the transient currents having the same direction in both conductors of the circuit.

Damping coils are installed on terminal cable poles and are connected: in circuits composited with 12-channel apparatus -- at the entrances of intermediate and terminal stations; in circuits not composited with the 12-channel apparatus and to telegraph conductors located in the same line with a composited circuit -- only at the entrances of amplifier stations; in the circuits and conductors of other lines having connections with lines having circuits composited with 12-channel apparatus -- with a distance of up to 20 m between lines. In the last case the coils are installed on one of the poles between the terminal cable poles of a line leading to an amplifying point.

Matching line-balance compensators serve to match the characteristic impedance of an overhead circuit composited in the frequency band up to 30 or 150 kc with the characteristic impedance of non-loaded entrance cables with paper cord or styroflex insulation of conductors. When matching compensators are used the entrance pole is equipped as shown in Figure 14.21.

Loading coils are used for loading of cable inserts. They are designed to match the input impedances of composited overhead circuits with cable inserts and to match the cable inserts with equipment when cables with styroflex cord or disc insulation of conductors are used.

The cables or conductors joining 12-channel composited circuits with loading coils, compensators, and damping coils must be as short as possible. Over the entire length of the lay they must be at least 5 cm apart. The cables or conductors must not be twisted together. The cables must be fastened so that the wind does not cause them to sway.

In order to protect the entrance cable and equipment at the station from excessive voltages special protection is provided at cable poles. The protective devices in cable boxes consist of RA-350 gas-filled arresters, but if there are streetcar or trolley-bus conductors on the section, the arresters are protected by installing heat-stable SN-05 fuses in front of them, which fuses will not be burned out by short lightning discharges.

The arrangement of cable boxes in which the protective devices are mounted is described in Chapter 17.

In compositing circuits up to 150 kc the protective equipment of all circuits is located in the boxes with the damping coils (ZK).

On circuits composited with voice-frequency telegraph, in order to insure reliable communications during storm, bleeding coils are installed on the crossarms and are included in the protective arrangements of damping coils.

A bleeding coil consists of two half-windings wound on a common core. Each of the half-windings of the coil is connected in series with an arrester, the direction of the turns of the half-winding being such that during operation of the arresters each half-winding's resistance for discharge currents becomes very small and for transmission currents very large.

If the arresters are connected without bleeding coils, then at the moment the arresters operate the two-wire circuit is shorted and, consequently, transmission ceases altogether. Upon connection of the half windings of the coil between the arresters their resistance for transmission currents is very great and hence communications will not be interrupted.

# CHAPTER 15. TRANSPOSITION OF TELEPHONE CIRCUITS

## 15.1. The Concept of Transposition of Telephone Circuits

A current-carrying conductor is surrounded by magnetic and electrical fields which give rise to an electromotive force (emf) and currents in nearby conductors. These currents arising in adjacent conductors on a communications line will interfere with normal telephone transmission along those conductors, hence they are known as interference currents and the phenomenon of the crossing of currents from one circuit to another is known as disturbance.

With two circuits on an overhead line it is easily observed that, due to the effect of one circuit on the other, in transmitting a telephone conversation over one circuit the conversation is heard in the second circuit. Moreover, by connecting a telephone receiver to each of the circuits, we may easily detect in them the strong noise due to the effect on these circuits caused by other communications lines, high-voltage lines, and other sources of interference.

In order to decrease mutual interference of telephone circuits and the effects of telegraph lines, high-voltage lines (lines for power transmission, railroad signalling and automatic blocking, electric railroads, etc) and in some cases radio stations, the conductors of telephone circuits are transposed.

Transposition is the change in relative position (crossing) of conductors on the poles at prescribed intervals. Moreover, in order that the transposition be effective and decrease disturbance, it is performed so that each circuit has its own, strictly calculated

arrangement (order of transposition) differing from the transposition arrangement of all other circuits. The order of transposition or the transposition arrangement is designated by numbers known as indexes. The shortest interval between transpositions (usually two spans) is known as an element. The intervals between transpositions may be equal to 2, 4, 8, 16, 32, 64, 128, and 256 spans (in other words 1, 2, 4, 8, 16, 32, 64, and 128 elements).

The transposition index is expressed by a number indicating how many elements are included in each interval between alternating transpositions. For example, if the transposition alternates every four spans or two elements, the transposition index will be 2; if the transposition is made every eight spans or every four elements, the tranposition index will be 4, etc. These numbers are referred to as indexes; they indicate the number of elements included within a transposition of one or another circuit. Thus, if it is said that a circuit is transposed according to an index of 4 or 8, this signifies that the transposition is made respectively every four or eight elements, that is, every 8 or 16 spans (Figure 15.1).

The length of the element depends on the type of line (that is, on the number of poles per kilometer and, hence, on the normal length of a span). In practice the length of a span is: 125 m with 16 poles per km (2 spans per 62.5 m); 100 m with 20 poles per km (2 spans per 50 m); 80 m with 25 poles per km (2 spans per 40 m).

If two basic (simple) arrangements (Figure 15.1) are laid one on the other, a third, compound arrangement is obtained. As is seen from the figure, the indexes of the basic arrangements are given in the designation of the resulting third arrangement; hence it is designated by the indexes 4-8. In this manner, by superimposing

all the remaining transposition arrangements, first in pairs, then in threes, etc (Figure 15.2), we obtain 120 different arrangements. In forming the compound arrangements from two simple arrangements, points at which the crosses coincide are eliminated.

In the transposition of telephone circuits the section of line between two repeater or terminal points is divided into units -- main units and short units.

A unit is the shortest length for which the largest index of one of the circuits in the transposition arrangement may be used. The number of elements in the unit is twice the largest index. The unit is identified by this number. Hence, a 128-element unit (with 64 the largest index) is the main unit and the 64-, 32-, 16-, and 8-element units are short units. Figure 15.1 shows a 16-element unit (8 being the largest index).

A line is laid out in units according to the repeater sections of circuits composited with apparatus of the 12-channel or 3-channel system. In the absence of nonferrous circuits, the lines are laid out in units according to the repeater sections of steel circuits. From the ends of the repeater section the line is divided into 128-element main units. If it is not possible to divide the line into a whole number of units, short units are used.

In dividing a unit into elements a variation in the length of individual elements is permitted: with an average element length of 125 m, a variation of ±11 m is permitted; with an average element length of 100 m, a variation of ±10 m is permitted; with an average element length of 80 m, a variation of ±8 is permitted. If local conditions dictate the erection of elements of

great length (due to overhead river crossings, gulley crossings, etc), they are permitted on the condition that the number of such elements over the length of a repeater section does not exceed: with an element length of 300 m, one; with an element length of 200 m, two; with an element length of 150 m, six.

Nonferrous circuits are distributed on poles according to the compositing frequency range, as shown in Table 15.1.

Steel conductors for noncomposited telephone circuits and telegraph conductors may occupy any position on the pole.

Transposition arrangements are planned in accordance with Instruktsiya po skreshchivaniyu telefonnykh tsepey vozdushnykh liniy svyazi [Instructions for Transposition of Telephone Circuits of Overhead Communications Lines] (Svyaz'izdat, 1947).

According to these instructions, nonferrous circuits which are to be composited in the range up to 150 kc must employ the following transposition indexes: 2.2-4, 1-2-32-64, and 1-4-16-32. In addition, when the element length is 125 m, index 2 is used instead of indexes 2-4 and index 1 is used instead of indexes 1-4-16-32. Steel circuits employ the following transposition indexes: 4, 8, 16, 8-16, 8-32, 16-32, 16-64, 4-8-16, 8-16-32, 8-16-64, 16-32-64, and 8-16-32-64.

The transposition indexes of the circuits are indicated behind the circuit locations on the pole. If it should be necessary to change the position of a circuit on the pole, this circuit is transposed according to the indexes corresponding to its new location on the pole. This change may be made only at the end of a unit. In changing the line profile at crossings (1-2 spans) the transposition remains unchanged in order not to use short units.

TABLE 15.1

DISTRIBUTION OF NONFERROUS CIRCUITS ON POLES

| Compositing frequency range | Profile number 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | Location number on pole | | | | | | |
| to 65 kc | 1, 5 | 1, 2, 3, 4 | 1, 2, 3, 4 | 1, 2, 3, 4, 9, 12 | 1, 2 | 1, 2, 6 | 1, 2, 6, 9 |
| to 150 kc | 1 | 1, 4 | 1, 4 | 1, 4, 9, 12 | 1 | 1, 6 | 1, 6 |

Branching of circuits from nonferrous conductors to other lines is made at the end of a unit or at the end of the eight element.

Steel circuits may be tapped from any pole. However, the best taps are made at the end of element number 4, 8, 16, 24, 32, 48, 64, 96, or 128.

Different sags as well as different distances between hooks, pins, etc cause a change of distance between the conductors of two circuits, thereby increasing the interaction of these circuits. Hence, in the erection and operation of a line it is necessary that all distances between circuits and all sags be established precisely and in no case should these deviate by values greater than those prescribed in the technical specifications, rules, and standards.

## 15.2. Tranposing the Conductors of Telephone Circuits

Nonferrous circuits on crossarms are transposed at points on steel brackets in the following manner. Wire straps are run around the necks of the insulators with their ends turned toward the adjacent spans. Then the line conductor at the first insulator in the stringing sequence is applied from the outer side, drawn up with pulleys, and adjusted. The conductor and the strap are then bound with a 160-cm length of tie wire. With the line conductor fastened

to the first insulator, the pulleys are slacked off and the conductor is brought over to the neck of the second insulator of the second bracket and tied in the same manner as on the first insulator.

The second conductor is tied in the same manner as the first conductor.

Steel circuits on crossarms are transposed within spans on stringing hooks. The rigging is performed in the following manner. The righthand conductor from pole No 1 crosses to pole No 2 to the insulator of the stringing hook (Figure 15.4) where it is tied as on an intermediate pole. From the stringing hook the conductor crosses to pole No 3 where it is placed on the lefthand insulator of the circuit (in the stringing sequence) and is fastened with an intermediate tie. The second (lefthand) conductor from pole No 1 crosses to pin insulator of pole No 2 and then to pole No 3 on the righthand side of the circuit.

Steel circuits and nonferrous circuits on hooks are transposed in spans with the use of L-brackets in the following manner. The upper conductor of the circuit from a hook on pole No 1 is transposed to pole No 2 (Figure 15.5) onto the righthand insulator of the L-bracket and fastened with tie wire to the neck of the insulator from the outside. Then the conductor is brought to pole No 3 and placed on the second hook of the circuit. The second conductor from the second hook of pole No 1 is brought to pole No 2, placed in the top groove of the insulator on the left of the L-bracket, and fastened with an intermediate tie. From pole No 2 the second conductor is brought to the upper hook of pole No 3 and tied to the top of the insulator with an intermediate tie.

In span transposition it must be kept in mind that the conductor must always be transposed in one direction, that is, in the clockwise direction.

# SECTION IV. CABLE INSERTS IN INTERCITY OVERHEAD COMMUNICATIONS LINES

## CHAPTER 16. TYPICAL CABLES FOR INSERTS IN OVERHEAD COMMUNICATIONS LINES

### 16.1. Description of Intercity Communications Cables

Overhead communications lines consist of the following elements: conductors, insulators, poles, and supporting devices (hooks, pins, crossarms).

Underground and submarine communications lines consist of insulated conductors twisted within a common braid and enclosed in a lead sheath over which (in underground cables) is laid an armor of steel tape or wire. Such communications lines are known as cable lines.

The conductors are insulated by paper tapes and paper cord (packing) as well as by tapes and cord made of plastic (styroflex).

Communications cables are divided into symmetrical, coaxial, and combined cables.

Symmetrical cables contain conductors twisted in pairs and quads.

In the pair twist two insulated conductors are uniformly twisted together (Figure 16.1). The conductors of the twisted pair are usually wrapped in one or two layers of paper tape, and if the pair must be shielded, it is also wrapped in a shield tape (Figure 16.2). The shield tape is 15-20 mm wide and is made of metallized paper (that is, paper covered with a very thin layer of metal, e. g., aluminum) or of copper or tin foil 0.07-0.1 mm thick.

In the quad twist four insulated conductors are twisted together. There are two methods of making the twist -- the star twist and the two-pair twist. In the star twist four conductors a, b, c, and d, in the arrangement shown in Figure 16.3, are twisted together in one group (a quad). With this twist speech circuits are formed by opposite conductors a-b and c-d.

In the two-pair twist two insulated conductors are first twisted into a pair and then two such pairs are twisted into a quad (Figure 16.4).

Coaxial cables contain coaxial pairs. The coaxial pair consists of an inner and an outer conductor, the latter being a copper tube with a lateral seam (Figure 16.5) over which two steel tapes are wound in spiral fashion. The tapes serve as a shield against external interference and give the coaxial pair the necessary mechanical strength.

A coaxial cable may contain two or more coaxial pairs. Figure 16.6 shows a coaxial cable containing four coaxial pairs. This cable also contains five quads for auxiliary communications and signalling.

A combined cable contains symmetrical quads as well as coaxial pairs.

In the construction of intercity overhead lines there arise occasions when the erection of overhead lines is very expensive, technically difficult, and leads to operational inconveniences. This occurs in the erection of overhead lines in densely populated localities, in crossing wide rivers, crossing electrified railroads, at entrances into structures, etc. In such cases it is often more convenient to lay cable. The cable used for this purpose is usually a symmetrical cable with star-twisted conductors.

In cables used as inserts in overhead lines the conductors are made of electrolytic copper in the form of solid wire with a diameter of 1.4, 1.2, 1.0, 0.9, or 0.8 mm. The conductors are spiral-wrapped in paper cord and over this with a layer of paper tape.

Inserts into overhead lines composited with a large number of communications channels may also use cables with conductors insulated by styroflex cord.

Telephone or telegraph communications may be established quickly over relatively small distances by the use of PTF-7 field cable (field telephone cable, seven conductors with rubber insulation in a bitumen-impregnated cotton braid or with a polyvinyl chloride insulation without sheathing).

## 16.2. Distinguishing Conductors, Pairs, and Quads in Cable

In order to facilitate locating a desired conductor in a cable during wiring and repair, the insulation of conductors, pairs, and quads is given distinctive colors, at the time of manufacture. Quadded conductors are either insulated with paper of different colors or the paper is streaked with the different colors. The conductors of one pair of a quad are red and uncolored (natural) and the other pair blue and green.

Each quad is wrapped with an open spiral of cotton thread or paper tape, the colors of which differ for the different pitches of twist.

In high-frequency cables, where all the quads have different pitches of twist, each quad in a lay may be distinguished by the

color of the thread or tape. In low-frequency cables, where only adjacent quads have different pitches of twist, for identification of a given quad in each lay two adjacent quads (the first and last) are wrapped with threads or tapes of such color as to distinguish them from one another and from the remaining quads of the given lay.

If a cable contains shielded pairs, then the insulation of the conductors of these pairs has the same color as the insulation of the pairs of a quad; hence, in order to distinguish one pair from another, the one pair may contain conductors with the insulation red and natural and the other pairs with blue and green insulation.

## 16.3. The Outer Protective Covering of the Cable

In developing the design of a cable the outer protective covering is chosen according to the conditions under which the cable will be laid and operated. The lead sheathing of a cable (the main purpose of which is to protect the core of the cable against penetration of moisture) is made of chemically pure lead with the addition of 0.4-0.8 percent of antimony in order to give it mechanical strength.

Cables designed to be laid in conduits are not armored. In this case the lead sheath does not require protection against mechanical injury.

Cables designed to be laid directly in the ground have an armor of two spirally wound steel tapes applied over the lead sheath. In order to avoid damaging the lead sheath in applying the steel armor, the sheath is covered with a layer of asphalted paper

and a pad of treated jute yarn. The armor is also covered with a layer of jute yarn impregnated with an asphalt compound. The outside of the cable is painted with a chalk solution so that the turns of cable on the reel will not stick together.

On the slopes of hills, in stringing conductors in shafts, etc, when longitudinal forces are acting on the cable an armor of flat or round wires is used.

In laying cable across rivers and lakes (where the cables may be stretched by constantly acting forces, the flow of water, and by coming in contact with the anchors of ships, submerged logs, etc) the cable armor is made of round galvanized steel wire with a diameter of 6 or 4 mm. Cables which are to be laid in rivers and lakes with unorganized ship traffic, with rapid water flow and a rocky bottom, with rafting and the formation of ground ice are provided with double armor consisting of two layers of steel wire with a diameter of 4-6 mm.

Armor of round wires with a diameter of 6 mm or double armor somewhat increases the cost of cable. Hence, in laying submarine cables they are often buried in riverbeds at a depth of 0.7-1 m, which permits the use of an armor of wires 4 mm in diameter or even permits laying cable with tape armor.

## 16.4. Cable Designations

Cables used for inserts contain star-twist quads and, according to the type of armor, are given the following designations: TZG, TZB, TZK, TZP. Here the letter T signifies "telephone," Z signifies "star-twist quads," and the last letter indicates the type of armor (B, armor of two steel tapes; K, armor of round wires; P, armor of flat wires; G, cable without armor in a lead sheath, that is, bare).

Cables are made with 3, 4, 7, 12, 14, 19, 24, 37 and more quads. Figure 16.7 shows the construction of a submarine cable with a single wire armor containing 12 star-twist quads (designation TZK).

Intercity symmetrical cables are designated, for example, as MKB 4x4x1.2 or MKSB 4x4x1.2. Here the letter M signifies "intercity," and the letter K "cable." The last letter indicates the type of armor. The presence of the letter S indicates that the conductors of the cable have styroflex insulation.

Coaxial cables have the designation KMB-4, which signifies "coaxial intercity, armored" (tape armor) and the numeral indicates the number of coaxial pairs.

Combined cables have the designation KMKB-4. The additional letter K here signifies "combined."

## CHAPTER 17. CABLE ACCESSORIES, INTERMEDIATE AND TERMINAL FACILITIES

### 17.1. Coupling and Branching Sleeves

In constructing cable line the individual lengths of cable are joined by the use of coupling sleeves. Lead sleeves only are used on unarmored cables, but on armored cables with tape or wire armor cast iron jackets are also used.

The dimensions of the coupling sleeves depend on the dimensions of the cable, the number of conductors in the cable, the diameter of the conductors, and the purpose of the sleeve (coupling, matching). Figure 17.1 and Table 17.1 give the dimensions and weight of lead coupling sleeves.

TABLE 17.1

DIMENSIONS OF LEAD COUPLING SLEEVES

| Dimensions, mm | | | | |
|---|---|---|---|---|
| a | b | c | d | e |
| cylindrical sleeves without slit | | | | |
| 50 | - | 250 | 40 | 2.5 |
| 70 | - | 400 | 40 | 3 |
| sleeves with longitudinal slit | | | | |
| 20 | 55 | 240 | 40 | - |
| 40 | 75 | 350 | 40 | - |

TABLE 17.2

DATA FOR CAST IRON JACKETS FOR LEAD SLEEVES

| Dimensions, mm | | | | Weight, kg | | Corresponding to type of sleeve with dimension a in Table 17.1 | |
|---|---|---|---|---|---|---|---|
| a | b | c | d | sleeve | sealing compound (approx.) | with longitudinal slit | cylindrical without slit |
| 325 | 425 | 130 | 40 | 8.1 | 1.2 | 20 | 50 |
| 400 | 515 | 150 | 50 | 12.7 | 2.0 | 30 | 60 |
| 500 | 615 | 180 | 60 | 17.5 | 2.9 | 40-50 | 70 |
| 625 | 755 | 220 | 80 | 30.0 | 5.5 | 60-70 | 95 |
| 725 | 855 | 235 | 100 | 45.0 | 8.3 | 80-90 | 115 |



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

A sketch of the cast iron jacket is given in Figure 17.2.

Branching sleeves or gloves are used where a cable with a large number of conductors must be tapped off into two cables or more with smaller numbers of conductors (for example, the cable entrance at a repeater or terminal point).

## 17.2. Boxes and Cable Shoes

Terminal fastenings at exchange cable entrances employ boxes which are installed on the cable entrance rack (VSK).

Boxes are made for 10, 20, and more symmetrical low-frequency cable pairs and shielded boxes are made for the connection of six shielded pairs or high-frequency circuits. The box consists of a cast iron housing, insulating strips in which are pressed copper sockets with pins to which the cable conductors are soldered, as well as coupling plugs by means of which the line cable conductors are connected with the exchange wiring.

Figure 17.3 shows a 10-pair box.

In rigging cable cases and installing intermediate distribution frames in cable vaults the terminal connections of cables are made by means of cable shoes.

The shoe consists of a lead housing and one or two ebonite caps with openings. Within the shoe the cable conductors are joined to PRG [rubber-insulated, flexible] conductors which are brought out through the openings in the ebonite caps. Nonferrous circuits are led into the cable case with RVChS conductor. The space between the outer and inner ebonite caps is filled with a sealing compound in order to prevent the entrance of moisture into the cable. Figure 17.4 shows assembled shoes.

## 17.3. Cable Cases

At points joining cable with overhead lines cable cases are installed in which arresters and fuses are placed to protect cable conductors against damage by lightning currents or currents from streetcar or trolleybus conductors in the event of accidental contact with communications conductors. As protective measures 350-v gas-filled, aluminum, two-electrode arresters (RA-350) and 0.5-a fuses (SN-0.5) with knife-edge or conical caps.

The wiring arrangements of arresters and fuses in cable cases will differ for telegraph conductors and steel and nonferrous telephone conductors. Figure 17.5a shows the arrangement for protection of telegraph conductors and Figure 17.5b shows the arrangement for protection of telephone circuits with steel conductors.

Figure 17.5c shows an arrangement for protection of circuit entrances along nonferrous conductors. In this case, in addition to the RA-350 arresters and SN-0.5 fuses, provision is made for bleeding coils (DK) and, where a cable insert is used, for damping coils (ZK) as well.

In the absence of streetcar and trolleybus conductors the SN-0.5 fuses are not installed.

Cable cases made for 16, 24, 32, and 40 conductors consist of two steel cases, one inside the other. A cable case is sketched in Figure 17.6 and its principal dimensions are given in Table 17.3.

TABLE 17.3

CABLE CASE DIMENSIONS

| No of | Dimensions, mm | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| conductors | a | b | c | d | e | f | g | k | l | m | n | o | p | q |
| 16 | 887 | 510 | 209 | 367 | 120 | 138.5 | 140 | 125 | 543 | 125 | 85 | 60 | 18.5 | 40 |
| 24 | 1,074 | 510 | 209 | 504 | 130 | 148.5 | 160 | 140 | 544 | 125 | 85 | 60 | 18.5 | 40 |
| 32 | 1,189 | 510 | 209 | 574 | 155 | 228.5 | 160 | 150 | 544 | 125 | 85 | 60 | 18.5 | 40 |
| 40 | 1,489 | 510 | 209 | 819 | 160 | 233.5 | 160 | 170 | 544 | 126 | 85 | 60 | 18.5 | 40 |

Cable cases are placed on cable poles equipped with a platform, steps for climbing onto the platform, and a lightning conductor.

Figure 17.7 shows a cable pole with a cable case installed.

## 17.4. Cable Vaults and Cabinets

In places where it is necessary to change connections between the conductors of different cables use is made of cable cabinets or cable vaults with intermediate panels.

The cable cabinet consists of two steel cases, one of which is located inside the other, and is mounted on a reinforced-concrete base. Installed in the inner cabinet is an insulating panel on which are mounted cross-connecting posts in the form of fuse bases with copper blades instead of fuses. Within the cabinet the cables terminate in cable shoes from which, by means of wire with rubber insulation, the conductors are connected with the cross-connecting posts.

Instead of the cross-connecting posts the cable cabinet may contain boxes in which the necessary switching may be performed.

With a large number of conductors on an overhead line, instead of a cable pole at the site of connection between the cable and the overhead line a cable terminal vault is sometimes used. Within it is installed a panel with fuses and gas-filled arresters as in the cable case.

# CHAPTER 18. LAYING AND RIGGING CABLES

## 18.1. Digging Trenches and Laying Underground Cable

Cable lines of communication are laid in a definite sequence.

First of all, the cables and cable accessories must be brought to storage places along the projected cable run. Then the trench is dug, the cable laid, the trench filled, and the couplings installed. The necessary electrical measurements are performed during the laying and rigging of the cable.

The cable and fittings received at the storage place must be subjected to careful external examination. The cable drums must be properly covered and the cable ends must be sealed and fastened on the drum. If the cable was transported under internal air pressure or gas pressure, then the air pressure within it is checked. Where there is no pressure within the cable the insulation resistance of the cable conductors is checked.

The cable drums are received at the work site on trucks. Transportation of the drums in the horizontal position (on the side) is not permitted. The drums are conveyed along the run in accordance with a previously prepared sheet listing the laying sequence numbers of the drums with the cable.

Before beginning excavation of the trench the cable run must be precisely marked off in accordance with the technical plan and working drawings. In marking off the run the following features must be noted: the side lines determining the width of the trench; underground structures intersecting the cable run; changes in trench depth, if the depth of the run is to vary.

String is used in marking off the run. Upon encountering an asphalt cover the run is marked off with chalk, and where chalk is not available it is marked off by scraping a groove. Points of intersection with other structures are marked by pegs with appropriate notes: cable, water pipe, etc.

In constructing new cable lines or in carrying out extensive cable repairs it is necessary to dig the trenches with special plows and trench diggers. Also, in laying cable, cable-layers are used which dig the trench, lay the cable, and fill the trench.

In digging the trench manually the earth must be thrown to one side and paving materials (cobblestones, asphalt, etc) are deposited in separate piles on the other side so that they be used in subsequent paving work.

The width and depth of the trench must be in accordance with the plan (80-100 cm). The bottom of the trench must be smooth and free of stones and rubble. The bottoms of trenches with hard, stony, or rocky ground are topped with a 10-cm layer of loose earth or sand to protect the cable against mechanical damage. In crossing other structures the depth of the trench must change gradually. The radius of turns in the trench must not be less than 15 times the diameter of the cable to be laid. The length of trench excavated in the working day must equal the length of cable to be laid in that day.

Unreeling and laying of cable in the trench may be performed:

Manually, when the drum is mounted on tripods, frame horses, or jacks and the workers carry the cable along the trench by hand;

mounting the drum on a specially equipped truck, a cable cart, or special frame horses;

with the use of a steel line and a winch, playing out the cable along special rollers installed along the edge or at the bottom of the trench.

In playing out the cable care must be exercised to avoid kinks in the cable. The cable must not hang from the worker's shoulders with such slack as to exceed the permissible radius of bend and to drag along the ground. The workers should be stationed at an average of every 3-5 m of cable length.

The cable must be laid in the middle of the trench without tension.

In laying the cable from a truck or cable cart one worker feeds the cable into the trench by hand and the others, standing in the trench, lay the cable.

In laying the cable entirely by hand the cable is first placed on the edge of the trench and is then lowered to the bottom.

Before covering the cable in the trench its length is measured with an accuracy of 10 cm, an air-pressure test of the lead sheath is made, and other necessary tests are performed. Then the position of the cable is measured relative to certain fixed features of the terrain and the data is entered on a plan sketch of the run.

After the testing and necessary measurements the cable is covered with a 10-cm layer of soft earth or sand. If the plan calls for a brick cover over the cable, the brick is layed over a layer of sand and is then covered with earth in layers of 15-20 cm individually tamped. In urban localities where pavement is to be layed after the cable is covered the fill earth is wetted down and tamped.

Pavement is restored over the trench after the earth has settled.

18.2. Mounting Coupling Sleeves

In constructing cable inserts for overhead lines the individual, factory-made construction lengths of cable are joined in the trench by the use of coupling sleeves. This entails a number of operations: work preparatory to mounting the sleeves, checking the cable, preparing the ends of the cable, etc.

Preliminary operations include digging a side ditch, erecting a tent, and preparing the sleeve for mounting.

In digging the side ditch care is taken to avoid injuring the laid cable with the crowbar or shovel. For the installation of a single sleeve (straight, matching) a ditch with sides of 1,400 and 1,600 mm and a depth of 1,100 mm is dug in firm ground. If two sleeves are to be placed in the ditch, the sides of the ditch are increased to 1,500 and 2,200 mm.

Over the open ditch a rigger's tent must be placed so that the entrance into the tent is in line with the cable on the downwind side.

The ends of the cable within the ditch are carefully bent and placed 30-45 cm aside from the line of the cable. The lead sheath is then checked for breaks by attaching a manometer to a valve (if there is one installed on the cable) or by puncturing the end seal of the cable. The dry compressed air with which the cable was filled in testing it after it was laid will escape with a hiss at the point of puncture.

If no compressed air is detected in the construction length of cable, the insulation resistance of the conductors is checked.

If the insulation resistance is up to specifications, the cable sheath is checked for holes by introducing air into the cable under pressure. If the pressure drops, it is necessary to determine the location of the sheath defect before mounting the sleeve.

If both lengths of cable which are to be joined prove to be in good condition, the cable ends are prepared. In the middle of the ditch, as shown in Figure 18.1, frame horses are placed to support the ends of the cables so that the turns of wire wrapped around the cable in laying it are opposite one another and are in line with the center of the sleeve.

The next step is to mark off the ends of the cable (Figure 18.2). The spacing of the markings depends on the type and dimensions of the sleeve. In marking off the ends of the cable use may be made of a template with inscribed markings for the given types of sleeves.

Having completed the marking, the outer jute covering is firmly wound with several turns of wire at the marks farthest from the cable ends. The center bindings made in laying the cable are removed, the outer jute covering is removed, and the armor is unwound and cut off at the marked places. The tape armor is removed by filing it with a triangular file and carefully breaking it off. It is necessary to exercise care in removing the tape armor in order not to damage the lead sheath. The sharp edges of the armor at the point of cutting must be removed with a file.

Armor wires may be cut to three-fourths of their thickness by hack saw and the wire may then be broken off.

After removing the armor the jute cushion is unwound to the end of the armor and then cut. The asphalt-impregnated paper tape is removed and the lead sheath is carefully cleaned with rags dipped in gasoline or kerosene. On the lead sheath of each cable end marks are made, on both sides of which the lead sheath is carefully cleaned and tinned. Moving back 40 mm from the marks toward the center of the sleeves (so that there will be room for soldering) a circular cut is made in the lead sheath of each cable end with a cable knife. Then two longitudinal cuts are made approximately 5 mm apart. The strip thus marked off is torn back with pliers and the lead sheath is then removed. The sequence of operations in removing the lead sheath is shown in Figure 18.3.

Smoothed by means of a burnishing stick, the lead sleeve is thoroughly wiped with a rag and lightly heated on the inside with a torch in order to eliminate moisture. The edges of the sleeve are trimmed, cleaned, and tinned.

If a cyclindrical sleeve is to be used, it is slipped over one of the cable ends.

At the end of the lead sheath the core of the cable is bound with two turns of calico stripping and the paper tape is removed from the core. The quads are then bent back and numbered. In order to keep the conductors in place each quad is twisted a bit and five or six quads are gathered in a bunch and bound with cotton stripping. The bunches are then carefully bent back against the lead sheath so as not to damage the insulation of the conductors. The shielded quads or pairs are bound with two turns of calico stripping 2-4 cm away from the lead sheath and the outer layer of paper tape, the shielding, and the inner layer of paper tape are carefully removed.

The readied quads are numbered by attaching at each end of cable a paper band with a number (written in ink or with a chemical crayon) corresponding to the quad joining sequence.

Joining copper conductors covered with paper insulation. Before joining the conductors the ditch is carefully cleared of the pieces of cable, lead, wire, and armor trimmed off during the preliminary operations and the cable ends are then firmly tied to the horses with rope. Before joining the conductors the necessary tools and materials are readied and the cable ends are designated A and B. In the Soviet Union the incoming end A is usually taken to be the end in the direction of Moscow and the outgoing end B is the end away from Moscow.

In joining the conductors in the coupling (straight) sleeves the quads, pairs, and conductors on the A side must be joined with the corresponding quads, pairs, and conductors on the B side having the same number and color coding.

Figure 18.4 shows the steps in this operation.

Before joining the conductors paper sleeves are slipped over them from one end of the cable.

At the point where the twist joint is to be made the conductors from ends A and B are laid crosswise and given two twists so that the paper insulation is held firmly between the twists of wire. Then the paper is torn back to the end of the twist and removed from the conductors. The conductors are then cleaned with emery paper.

The bared wires are lined up with one another. Holding the wires between the left thumb and index finger 5 cm from the bottom of the twist, the wires are bent 90 degrees with the right hand and twisted. The length of the twist must be approximately 30 mm. The remaining three conductors of the quad are twisted in the same manner, all four of the twists being made at the same place. The ends of all twists of the quad are then soldered without the use of acid. The solder is applied over 10 mm at the end of the twist.

The soldered twists are bent back away from the side on which the paper sleeves were placed. The paper sleeves are then slid over the joints and are marked with grouping (numbering) bands. If no grouping bands are available, the quads on both sides of the paper sleeves are tied with thread and the thread is crossed over the sleeves and pulled tight. The excess thread is cut off. Colored strands by which the quads are distinguished are also fastened with thread.

The other quads are joined so that the joints are uniformly distributed over the length of the coupling sleeve.

The conductors are soldered with a tetrahdral soldering point of red copper, the tip of which is cleaned with sal ammoniac in block form. Figure 18.5 shows another type of soldering instrument. The working portion (brass) of this device contains a recess in which the solder is placed. Before soldering the conductors the instrument is heated and brought to the twist joint. The latter is immersed in the solder for 1-2 seconds and then coated with rosin. The joint is dipped in the solder a second time. Since the twist is fully enveloped by the solder, this method of soldering is more rapid and reliable and results in maximum economy of the solder.

When all the pairs and quads have been joined the cable is covered with steel semi-cylinders (Figure 18.6) and they are uniformly heated with one or two torches until the paper acquires the rustling sound characteristic of dryness. The semi-cylinders are then removed and the jointing area is wrapped with several layers of calico tape or cable paper, proceeding from the middle of the area to one end and back to the other end and then again to the center, where the wrapping is tied with a knot.

A note giving the date of installation and the names of the solderer and his assistant is placed in the lead sleeve and it is placed over the jointing area.

If a sleeve with one or two longitudinal slits is installed, it is firmly bound along the middle with several turns of wire. If a cylindrical sleeve without a slit is installed, its ends are pressed snugly around the lead sheath by means of a wooden mallet.

Both on the sleeve and the cable sheath the surfaces to be soldered must be cleaned until they shine, for lead exposed to air oxidizes (darkens) and oxidized lead surfaces will not solder together even though solder and flux be applied. The ends of the sleeve must be cleaned and tinned not only on the outside but also on the inside, for the strongest joint will be obtained when the solder runs into the space between the cable sheath and the inner surface of the sleeve.

The soldering area must be heated by means of a benzene torch. In soldering the sleeve the torch flame must be blue-white. A red flame with soot is not suitable for soldering, since it contaminates the joint.

Lead sleeves are soldered with POS-30 solder (solder containing 30 percent tin and 70 percent lead). First the lengthwise or lateral seams are soldered and then the ends of the sleeve are soldered.

The sleeve or the cable must not be moved during the soldering process, for this may result in cracks in the hot layer of solder. Hence, the other (unsoldered) end of the sleeve must first be temporarily soldered to the lead sheath of the cable at one or two places. After joining several lengths of cable, the lead sleeves are checked for hermiticity by subjecting them to a pressure of 0.5 atmospheres for a period of two days.

When the soldered lead sleeve has cooled the armor is connected with the lead sheath. In a cleaned and tinned area of the tape or wire armor 3-4 turns of tinned copper wire with a diameter of 1.4 mm are soldered to the armor. This wire is then joined with the lead sheath by making 3-4 turns and soldering it to the sheath. The wire is soldered to the lead without using acid and is soldered to the armor with the use of acid and subsequent neutralization by the application of an alkali.

In addition to connecting the armor with the lead sheath, the armor of one end of the cable is connected with the armor of the other end by a copper strip 1.25x0.3 cm or by a copper wire, either by direct soldering or welding of two armor wires preserved in stripping the armor or by means of two wires with a diameter of 2 mm soldered to the tape armor.

In installing the cast iron sleeve (protective cover) the collars are first removed from both ends of the sleeve. The two halves of the sleeve are separated and cleaned. The cover of the port on the upper half of the sleeve is removed, after which the screws are again fastened in the holes. Beneath the lead sleeve on the horses the lower half of the cast iron sleeve is carefully put in place. The recesses in the lower half of the iron sleeve are packed with the jute removed from the cable or with rubber lining.

The outer jute layer of the cable is wrapped with treated paper stripping or insulating cardboard to a thickness equal to the inner diameter of the collar of the protective sleeve. Then the upper half of the iron sleeve is put in place and the bolts are tightened, drawing both halves of the sleeve together so that the cable is firmly gripped by the collars. After this the sleeve is removed from the horses and laid at the bottom of the ditch where it is filled with MB-100 compound. The compound is heated in an enameled kettle and is poured into the sleeve at a temperature of 130-140° C. The compound is made non-freezing by the addition of 5 percent (by weight) machine or transformer oil to the heated compound.

The compound is poured into the sleeve until it reaches the edge of the port. At intervals of 5-10 minutes, during which the compound cools and settles, compound is added to the sleeve until settling ceases. During this process the rest of the compound must be continually heated in the kettle.

When the compound has cooled the cover is placed on the port and fastened with bolts. All nuts and bolts of the sleeve as well as the points of exit of the cable from the sleeve and both armor wires are sealed with the same compound. With the sleeve installed the ditch is filled with earth and the site is marked with a surveyor's peg.

## CHAPTER 19. RIVER CABLE CROSSINGS

### 19.1. Laying Submarine Cable

Where it is not necessary to bury cable in the riverbed the most widely used method of laying cable across a river is by means of barge, boat, or raft. A phantom view of the barge equipment for such laying is shown in Figure 19.1. A wooden flooring on the bottom of the barge supports and mounts with a reel. A lowering sheave is located in the stern. The cable is fed along a guide roller mounted on the deck. Tension of the cable in descent is controlled by a brake consisting of two beams which are brought against the sides of the reel by means of a rope with pulleys.

The barge is towed along the chosen run by a tugboat or launch. In the absence of a tugboat the barge may be moved by means of anchors. Three anchors are used for this purpose. One anchor is carried ahead on a small boat and thrown into the water. The rope attached to this anchor is then pulled in by means of a winch until the barge is next to the anchor. Then the second anchor is carried ahead and thrown into the water while the first anchor is raised. The barge moves from anchor to anchor until the opposite shore is reached.

The third anchor is used to keep the barge from drifting with the current.

On small rivers with slow currents (up to 0.5 km/hr) the submarine cable may be laid by using airtight barrels, a steel cable, and a winch installed on the opposite shore. One end of the cable is wound around the winch and the other end is fastened to the cable which is to be laid. During movement of the barge, as the cable is lowered into the water it is suspended from the barrels, which prevents the cable from settling to the bottom. The distance between barrels depends on the weight of the cable and is so chosen that not more than three-fourths of the barrel is under water. When the end of the cable is brought to the opposite shore, workers take a small boat along the cable and unfasten it from the barrels. The arrangement for laying cable with the use of barrels is shown in Figure 19.2.

If local conditions permit, the river may first be spanned with a pontoon bridge over the projected submarine cable run and the cable temporarily placed on the bridge. The cable is subsequently lowered into the water on the downstream side of the bridge.

It is sometimes necessary to lay cable across a frozen river. In such cases this is best done in spring before the ice movement, when the air temperature is zero or slightly above. In order to lay the cable in a chosen place in the ice a trench is cut in isolated squares so that a layer of ice about 5 cm thick remains at the bottom of the trench. The remaining walls are broken down and the ice is chipped away to the last layer at the bottom of the trench. The cable is then laid along the trench and lowered into it.

Choice of a method of burying cable in a riverbed depends on the width of the river, the profile of the river crossing, the nature of the ground, etc. A trench may be dug in a riverbed by means of a dredge, after which the cable is placed in the trench by one of the methods described above. The position of the cable in the trench is checked by divers.

The use of a dredge in burying a cable is expensive, for it is necessary to dig a trench of considerable width and depth so that it will not be filled with drifting sand before the cable is laid.

Success has recently been achieved in burying cable in a riverbed by the use of a cable layer. In this case the entire length of cable which is to be laid must be placed on the reel, that is, the width of the river must be on the order of 350-400 meters. In using the cable layer to lay the cable one end of a steel cable is fastened to the cable layer and the other end is carried to the opposite shore where it is wound on a winch.

The locations where the cable is to be laid is carefully examined. The bed is checked for submerged objects and under-water rocks which may interfere with the progress of the cable layer.

## 19.2. Warning Signals at Submarine Cable Crossings

In order to warn the crews of passing tugs and floats of the location of a submarine cable, crossing signal poles are erected on the higher shore. On rivers wider than 300 m two signal poles with heights of 9 and 13 m are erected 100 m apart both upstream and downstream from the site of the crossing, as shown in Figure 19.3.

During the day the signal is a circular red disc with a horizontal white band 30 cm wide across the middle, and at night the signal is a triangular lantern with yellow glass.

## CHAPTER 20. ELECTRICAL CHARACTERISTICS OF CIRCUITS AND LOCATING FAULTS ON LINES

### 20.1. Electrical Characteristics of Overhead and Cable Communications Lines

For transmission of the energy of electrical oscillations of the transmitter of one telephone set to the receiver of another telephone set overhead and cable lines are employed. The forward and return conductors (copper, bimetallic, steel) connected to the equipment are known as the circuit.

The circuits of overhead and cable lines are characterized electrically by four valves known as the circuit parameters. These are the resistance, the insulation conductance, the capacitance, and the inductance.

The electrical parameters of a circuit may be calculated on the basis of data for the material of the conductors, the dimensions of the line, the relative placement of the conductors, and other conditions. Knowing the electrical parameters, the expected quality of telephone or telegraph transmission for different lengths of the given type of line may be determined. Or, conversely, in order to achieve good quality of telephone or telegraph transmission it is possible to determine what the electrical parameters of a planned line of given length must be.

The resistance per km of a two-wire direct-current circuit depends on the material and diameter of the conductor and is determined from the formula:

$$R = \rho \frac{l}{S} = \rho \frac{2,000}{S} \text{ ohms/km.}$$

Here S is the cross-sectional area of the conductor and is equal to $\frac{\pi d^2}{4}$ mm$^2$ (where d is the diameter of the conductor in mm, $\pi$ = 3.14), and $\rho$ is the resistivity of the material of the conductor.

Data on the electrical resistance of circuits of the most commonly used conductors on overhead and cable lines are given in Table 20.1.

TABLE 20.1

MAXIMUM RESISTANCE (OHMS) PER KM OF

CIRCUIT AT TEMPERATURE OF 20° C

| Conductor | Diameter of conductors, mm: Overhead line 5 | 4 | 3 | Cable line 0.8 | 0.9 | 1.0 | 1.2 | 1.4 |
|---|---|---|---|---|---|---|---|---|
| Copper | - | 2.84 | 5.04 | 72.2 | 57.0 | 47.0 | 32.8 | 23.8 |
| | 14.08 | 22.0 | 39.1 | | | | | |
| Steel | 7.04 | 11.0 | 19.55 | - | - | - | - | - |
| Bimetal | - | 6.44 | - | - | - | - | - | - |
| Aldrey | 3.78 | 6.00 | 10.45 | - | - | - | - | - |

The resistance of a single conductor (for example, a telegraph wire) is half the value given in the table. In Table 20.1 these values are given for steel conductors (in the denominator).

For high-quality telephone communications along a two-wire circuit, in addition to other conditions, it is important that the

resistances of both conductors forming this circuit be as evenly matched as possible. Actually, due to unequal deterioration of the conductors along the length of the line, the resistances of these conductors may differ (ohmic asymmetry). Hence, norms have been established for permissible deviation in the resistances of the circuit conductors.

The difference in the resistances of the circuit conductors (asymmetry) must not exceed two ohms for nonferrous conductors, five ohms for steel conductors with a diameter of 5-4 mm, and ten ohms for steel conductors with a diameter of 3 mm. For example, if the resistance of one conductor of a copper circuit is 350 ohms and of the other conductor 353 ohms, an asymmetry of 353-350 = 3 ohms (that is, more than two ohms) will exist and hence the asymmetry of the circuit will not lie within the permitted limit. A large ohmic asymmetry may be the result of inserting into one of the circuit conductors a wire of a different material or diameter, a poor weld or soldered joint, etc.

The values given in Table 20.1 are for a direct-current circuit. However, in achieving telephone and telegraph communications over a line alternating currents of different frequencies are transmitted; hence, the resistance of the conductor proves greater than with direct current. This occurs because with an increase in frequency the current density over the cross-section of the conductor ceases to be uniform as in the case of direct current. The current tends to concentrate in the areas of the conductor near the surface and at very high frequencies to flow along the surface. This phenomenon is known as the "skin effect." It causes an increase in the resistance because the cross-sectional area over which the current flows actually becomes smaller and this, as we already know, leads to an increase in resistance.

The resistance of conductors to alternating current may be several times greater than their resistance to direct current. For example, the resistance of copper conductors with a diameter of 3 mm at a frequency of 100 kc is four times greater than the d-c resistance.

Insulation conductance of overhead circuits. Let us connect at the beginning of a two-wire line one kilometer long a battery and a d-c galvanometer but leave the end of this line open (Figure 20.1).

Upon closing switch K, despite the open end of the line, the galvanometer needle is deflected and indicates the presence of current. How does this current arise in an open circuit? In answering this question it need only be pointed out that, however excellent the material of the insulators on which the conductors are fastened, it will conduct electric current, though only weakly. In addition, the surface of an insulator is usually covered with a thin layer of dust and soot, which has an adverse effect on the insulating properties of the insulator. When an electric current flows along the conductors, at the points where the conductors are fastened part of the current across the insulators, poles, or a crossarm flows from one conductor to the other and returns to the battery. The current branches out at each pole and over one kilometer of line it branches out at 20-25 points, depending on the number of poles erected per kilometer of line.

How to determine the insulation conductance was stated in Chapter 2. In determining the insulation conductance of an overhead circuit it suffices to find the value of the insulation resistance of the circuit. Then the insulation conductance is expressed as the reciprocal of the insulation resistance; that is,

$$G_0 = \frac{1}{Ro} \text{ ohms/km.}$$

The conductors of a circuit in good condition should have an insulation resistance relative to ground of not less than 2 megohms per kilometer and an insulation conductance of not more than 0.5 micromho per kilometer under the worst weather conditions (dampness, fog). In addition, the insulation resistance of the conductors of the circuit relative to ground must not differ by more than 30 percent. If, instead of the battery, an a-c generator with a frequency of 2.4 kc, for example, is connected in a two-wire line one kilometer long and then the insulation conductance of the line is measured, it will be seen that with alternating current the conductance is greater than with direct current. During frost and icing conditions the conductance with alternating current increases considerably, especially in the transmission of high-frequency currents. This somewhat lowers the quality of telephone communications and sometimes makes them impossible.

Inductance of communications lines. If two conductors each one kilometer long are placed parallel to one another at a certain distance and connected with a source of direct current, with the passage of the direct current along the conductors a constant magnetic field is formed around the conductors. The magnitude of the magnetic flux between the conductors depends only on the distance between them. The greater this distance, the greater the magnetic flux between the conductors.

During the flow of current there also arises a magnetic flux within the conductors, the magnitude of which depends on the material and diameter of the conductors. The magnetic flux of a copper conductor is less than that of a steel conductor, and the

magnetic flux of a bimetallic conductor is greater than that of a copper conductor but less than that of a steel conductor. This is explained by the fact that the magnetic lines of force in a steel conductor are somewhat denser than in a copper conductor.

If the magnetic flux per kilometer of a two-wire line is divided by the value of the current in the conductors, we obtain the magnetic flux per ampere. The value of magnetic flux per unit of current is known as the coefficient of self-induction or simply the inductance per km of circuit of a two-wire line.

The inductance of the circuit will not remain constant if an alternating current of varying frequency flows along the conductors. With an increase in frequency the inductance decreases but little.

Circuit capacitance of communications lines. Let us place two conductors of the same material and one kilometer in length so that they are parallel and a certain distance apart. These conductors may be regarded as the plates of a capacitor between which is located a dielectric (air) with a dielectric constant approximately equal to unity.

Numerous measurements of the capacitance of two-wire circuits have shown that it depends but little on the frequency of the current. Hence, for all practical purposes we may consider that with a given diameter of conductors and a given distance between them the capacitance of the circuit is a constant value. The smaller the distance between the conductors and the greater the diameter, the greater the capacitance of the line. Hence, a circuit with conductors strung on crossarms has a greater capacitance than a circuit with

conductors strung on hooks. We will remember that the capacitance of a circuit is designated by the letter C and is expressed in farads (f) or microfarads ($\mu$f) per kilometer of length. The capacitance of the circuit does not depend on the material of the conductors.

The concept of attenuation. In evaluating telephone and telegraph circuits with respect to the signals transmitted along them the concept of circuit attentuation is employed. An understanding of circuit attenuation may be obtained from an examination of the simplest case of d-c telegraph transmission along a single-wire telegraph circuit. This permits eliminating the effect of circuit capacitance and inductances from consideration and dealing only with the resistance of the conductor and the insulation conductance (current leakage to ground). Current leakage, as is known, will occur at each insulator from which the conductor is strung, and the telegraph signal, in traveling from the beginning of the line to the end, will gradually weaken (attenuate) as a result of the fact that part of the current along the way will be diverted through the insulators, pins, crossarms, and poles to ground and will return to the other pole of the battery at the beginning of the line and also as a result of the expenditure of electrical energy in heating the conductors and insulators. Knowing the values of conductor resistance and insulation conductance and using Ohm's and Kirchof's laws, we may determine the value of the current at the end of the line. The ratio of the current at the beginning of the line to the current at the end of the line indicates the extent of the attenuation of the signal in traveling along the line. Communications engineering does not employ the simple ratio of the currents or voltages but the natural logarithms of these ratios.

The attenuation is expressed in nepers. Where the ratio of the currents or voltages is given per kilometer of circuit it is referred to as the "kilometric attenuation of the circuit."

As the current travels along the circuit it is affected not only by the circuit resistance and conductance but also by the capacitance and inductance, which do not remain constant for different current frequencies.

## 20.2. D-C Measurements

The operation of overhead communications lines requires the regular measurement of the ohmic resistance of conductors, the ohmic asymmetry of conductors, the insulation resistance of the conductors, etc. Results of the measurements permit evaluation of the condition of the circuits. In addition, systematic measurements and the data of these measurements permit accurate location of a line fault in the event of a breakdown.

Disturbances of telegraph and telephone communications due to line faults may be distinguished by nature as: interruption of current in the circuit (break); contact of a conductor with ground (ground); contact between conductors (short); a drop in insulation resistance and different resistances for each of the conductors of the telephone circuit (asymmetry).

Interruption of the current in a circuit (a break) is observed when a conductor on the line is broken and hangs without touching the ground or lies on dry sand or snow (during a severe frost), when the fuses in cable cases burn out, when the test clamps on test poles are not operating properly, and in other cases where poor contact is observed on the line.

Contact of a conductor with ground is observed when a broken conductor or one that has fallen from its insulators lies on the ground or on objects in contact with the ground with the result that the current is diverted from the conductor to ground.

Contact between conductors is observed when the conductors on a line touch one another with the result that the currents flowing in them may pass from one conductor to the other.

A drop in insulation resistance is observed where the insulators on a line are fouled with dirt or broken.

Asymmetry of conductors (where there is a difference in the resistances of the conductors of a circuit) arises due to poor contact at some joint in a conductor or due to the presence of an insert of wire of a different diameter or material.

Voltmeter and Ammeter Method of Measuring Resistance. Figure 20.2 shows the diagram for connecting an ammeter (a) and a voltmeter (v) in an electrical circuit. In order to measure the resistance $R_1$ it is necessary to determine the value of the current I with an ammeter and the voltage U with a voltmeter connected to terminals a and b and then to apply Ohm's law.

Example 20.1. The voltmeter reading is 5 v and the ammeter reading 0.5 a. What is the resistance of R?

Solution. According to Ohm's law, $R = \frac{U}{I} = \frac{5}{0.5} = 10$ ohms.

The value of resistance $R_1$ may be determined with only one voltmeter (Figure 20.3) if the value of resistance $R_2$ is known. For this purpose a voltmeter is first used to measure the voltage drop $U_1$ between points a and b and then the voltage drop $U_2$ between points c and d. The resistance $R_1$ may then be calculated from the formula $R_1 = R_2 \frac{U_1}{U_2}$.

Example 20.2. Resistance $R_2 = 10$ ohms (Figure 20.3) and the voltage drop $U_2$ between points c and d is 12 v. Determine the value of resistance $R_1$ at which the voltage drop $U_1$ is 8 v.

Solution. $R = 10 \frac{8}{12} = 6.67$ ohms.

Measuring Resistance with an Ohmmeter or a Megohmmeter. Let us create an electrical circuit (Figure 20.4) with a battery E, a galvanometer with resistance $R_0$, a variable resistor R which may assume certain known values, and a switch K. By closing switch K when the variable resistance is zero we obtain the maximum deflection of the galvanometer needle. This position we mark as zero. Then, by varying the value of resistor R we will obtain different deflections of the galvanometer needle. If we mark the galvanometer scale with divisions corresponding to the known values of the resistor, the instrument will then be graduated in units of resistance (in ohms). If we connect an unknown resistance to the terminals of such an instrument, the needle of the instrument will indicate the value of this resistance. Since the voltage of a battery changes in the course of time, the ohmmeter is provided with a means of adjusting the instrument, that is, a means of resetting the needle of the instrument at the zero position.

Large resistances (for example, the insulation resistance of conductors) may be measured by means of a voltmeter with a large internal resistance or by means of a megohmmeter. Figure 20.5 shows an arrangement for measuring the insulation resistance of conductors by means of a voltmeter. The insulation resistance $R_x$ of the conductors is calculated from the formula.

$$R_x = R \left( \frac{E}{U} - 1 \right) \text{ ohms},$$

where E is the voltage determined from a voltmeter connected to the battery terminals, U is the voltage determined from a voltmeter connected to the conductors the insulation resistance of which is to be measured, and R is the internal resistance of the voltmeter.

Example 20.3. Determine the insulation resistance over one km of a conductor where the internal resistance R of the voltmeter is 0.1 megohm, the battery voltage E is 150 v, the voltmeter reading U is 15 v, and the length of the conductor is 100 km.

The insulation resistance over 100 km of the conductor is

$$R_x = 0.1 \left( \frac{150}{15} - 1 \right) = 0.9 \text{ megohm.}$$

The insulation resistance over one km of the conductor will be 100 times greater (see Chapter 2, example 2.7), that is, 0.9 x 100 = 90 megohms.

The megohmmeter or megger (Figure 20.6) operates in the same manner as the ohmmeter. Instead of a battery, the power supply in this instrument is a small d-c generator which is driven by hand. The megohmmeter generator may provide the circuit with a d-c voltage of 110-220 v. The internal resistance of the galvanometer is very large. The megohmmeter has a pushbutton for checking the measuring voltage and terminals for connection of the line conductors. In conducting measurements the instrument must be in a perfectly level position.

The measuring procedure is extremely simple. Connecting the "ground" and the conductor which is to be measured to the terminal clamps of the megohmmeter, depress the test button and at the same

time begin turning the generator handle at such a rate that the needle of the instrument remains at the red mark on the scale. Then, continuing to turn the handle at the same rate, release the button and read the indication of the instrument. The value of the insulation resistance is read from the scale, which is graduated in megohms.

In measuring the insulation resistance of the conductors of a cable the instrument reading is made only after turning the generator handle for a period of one minute.

There are megohmmeters which can provide the circuit with 500 v and 1,000 v and can measure up to 1,000 megohms. For the measurement of the insulation resistance of the conductors of a cable the megohmmeters with measuring ranges up to 1,000 megohms are more suitable.

The most accurate method for measuring resistances is the bridge method. This method of measuring employs a circuit consisting of three resistors (A, B, $R_r$) and an unknown resistance $R_x$, a galvanometer with the zero position in the center of the scale, switches $K_1$ and $K_2$, and a battery E connected as shown in Figure 20.7. Resistors A and B are known as the balance arms of the bridge, $R_r$ is the reference resistor, and $R_x$ is the resistance to be measured.

The arrangement consists essentially of two parallel circuits in which two currents $i_1$ and $i_2$ flow at the same time. Between points a and b there is connected a sensitive instrument across which current flows when there is a difference of potential between these points. There is no difference of potential between points a and b when $AR_r = BR_x$, whence

$$R_x = \frac{A}{B} R_r.$$

In order to measure resistance with the aid of the bridge the wires or cable conductors are shorted at the far end.

The measuring procedure is as follows. Having selected a given ratio (1/1, 1/10, 1/100, 1/1000) for resistors A and B, press switch $K_1$, thereby connecting the battery circuit. Switch $K_2$ is then pressed, connecting the galvanometer circuit. The galvanometer will be deflected to the right or left. Then release switch $K_2$ and change resistor $R_r$. Again press switch $K_2$ and observe the galvanometer needle. Resistor $R_r$ is varied until the galvanometer needle is in the zero position. Resistance $R_x$ may then determined from the formula

$$R_x = R_r \frac{A}{B}.$$

Asymmetry of conductors ($R_a - R_b$) may be measured by the three-sum (three-loop) method and by the grounded-loop method.

For measurement of asymmetry by the three-sum method an auxiliary wire or conductor must be used. All three of the conductors of the cable are shorted at the far end as shown in Figure 20.8. The resistances of the loops consisting of conductors a-b, a-p, and b-p are measured by the method already described. These measurements yield the values $R_1$, $R_2$, and $R_3$. The resistance of each conductor may then be determined from the formulas:

$$R_a = \frac{R_1+R_2-R_3}{2} \text{ ohms}; \qquad R_b = \frac{R_1+R_3-R_2}{2} \text{ ohms};$$

$$R_p = \frac{R_2+R_3-R_1}{2} \text{ ohms}.$$

From here the asymmetry of conductors $R_a$ and $R_b$ may easily be calculated. This method provides inadequate accuracy of results, hence the grounded-loop method is used in measuring asymmetry, since its results are more accurate.

In measuring the resistance asymmetry of wires or conductors by the grounded-loop method the pair of conductors which is to be measured is shorted at the far end and grounded. By varying resistance $R_r$ (Figure 20.9), the balance condition of the bridge is attained (that is, the condition in which the galvanometer needle is located at the zero position). Resistor $R_r$ will then indicate the value of asymmetry in ohms. By means of switch S, resistor $R_r$ should always be joined with the conductor with the lesser resistance.

Before measuring the asymmetry the zero position of the bridge should be checked, for it may not always coincide with the zero point of the galvanometer.

## 20.3. Locating Circuit Faults

The bridge method is widely used in locating faults in cable conductors or overhead conductors. If a short exists between two conductors, it may be located by first measuring the loop resistance of the conductors from the station to the location of the short (Figure 20.10) and then determining the distance to the fault by dividing the measured resistance by the loop-kilometer resistance value for conductors of the given diameter at the given temperature (for example, Table 20.1) or the latter resistance (for copper conductors) may be calculated from the formula $R = \frac{44.8}{d^2}$.

Example 20.4. The diameter of the shorted conductors of a cable is 0.9 mm. Determine the distance $l$ to the point of the short circuit if the bridge reading for $R_x$ is 82 ohms.

Solution. The loop-kilometer resistance for cable conductors with a diameter of 0.9 mm may be calculated as

$$R = \frac{44.8}{d^2} = \frac{44.8}{0.92} = 55.3 \text{ ohms per km;}$$

hence,

$$l = \frac{R_x}{R} = \frac{82}{55.3} = 1.485 \text{ km.}$$

If the conductors are in loose contact at the point of the short (as is often the case), then the value measured at the bridge will include both the resistance of the loop and the resistance of the point of contact of the conductors. In such cases it is not possible to locate the fault immediately; but it is necessary to perform the measurement twice in order to locate the fault accurately. In order to determine whether or not the contact at the point of the short is loose, the measurements are first performed with the conductors open at the ends and then shorted. If the results of the measurements in both cases are identical, the additional resistance at the point of the fault is zero. If the results of measurement of the resistance with the conductors shorted at the end are smaller, this indicates that the fault has an additional resistance and the actual location of the fault (Figure 20.10) will be closer than 1.485 km. To determine the precise location of the fault in this case it is necessary to measure the resistance of the conductors from both ends of the cable and to calculate the distances with the assumption that there is no additional resistance at the location of the fault.

If the distance is calculated on the basis of measurements made from the near end, it will be greater than the actual distance to the fault, and if it is calculated on the basis of measurements made from the far end, it will be less than the actual distance. The average of these two distances will be the actual distance to the fault.

In practice it is often inconvenient to carry the instrument to the other end of the cable, and, if there is available a pair of non-faulted conductors, the measurements are performed as shown in Figure 20.11. In this case it is necessary to know the resistance of the latter pair, which can be obtained by measurement.

Example 20.5. The non-faulted pair in Figure 20.11 has a resistance of 63 ohms. When it is connected to the defective pair (as shown in the figure) the measured resistance is 108 ohms. Upon direct measurement of the defective pair (as shown in Figure 20.10) the resistance reading is 37 ohms. If the conductors have a diameter of 0.9 mm, what is the distance to the fault and what is the contact resistance?

Solution. At first we shall assume that the contact resistance is zero. In the previous example calculation showed the resistance of conductors with a diameter of 0.9 mm is 55.3 ohms. Then the probable distance from the near end to the fault will be:

$$l_1 = \frac{37}{55.3} = 0.67 \text{ km.}$$

The length of the operating pair is

$$L = \frac{63}{55.3} = 1.14 \text{ km.}$$

The probable distance from the far end to the fault is

$$l_2 = \frac{108}{55.3} - 1.14 = 0.82 \text{ km.}$$

The actual distance $l_x$ is equal to the average value of the distances $l_1 = 0.67$ km and $l_2 = 1.14 - 0.82 = 0.32$ km; that is

$$l_x = \frac{0.67 + 0.32}{2} = \frac{0.99}{2} = 0.495 \text{ km.}$$

In measuring the distance from the near end the contact resistance resulted in an error of 0.67–0.495 = 0.175 km of cable pair. Expressing this in units of resistance, we obtain 0.175 x 55.3 = 9.65 ohms, which is the value of the contact resistance.

With a constant ratio for the two arms the bridge method may be used in locating faults due to low insulation of conductors as well as to contact between conductors. Figure 20.12 shows the arrangement of this method in measuring to the point of grounding at one conductor. Variable resistor $R_r$ is connected in series with the defective conductor. When the bridge has been balanced by changing $R_r$ it will indicate that resistance R in the formula $R_x = R \frac{A}{B}$ is equal to the loop resistance of the circuit from the point of the fault to the far end provided that arms A and B are equal. Actually, examining Figure 20.12, we see that resistor $R_r$ is connected in series with the defective conductor, and since the resistance of the defective conductor from the bridge to the fault is balanced by an equal length of the good conductor, with the bridge balanced resistance $R_x$ is equal to the resistance of the loop from the far end to the point of fault.

A variant method of measuring with a bridge with a fixed ratio of the two arms may be employed for determining ohmic asymmetry. Figure 20.13a shows the arrangement used for measurements in this case. All the conductors are shorted at the far end, as would be done if the loop resistance were to be measured. One of the good conductors is connected to the battery. Two of the remaining conductors are connected to the bridge and resistor $R_r$ is adjusted to balance the bridge. If the bridge does not balance, this will indicate that the higher conductor resistance is connected in

series with resistor R [sic]. Hence it is necessary to change the conductor connection. If arms A and B are equal, then the value of $R_r$ will be equal to the difference between the resistances of the two conductors and the value of the asymmetry is obtained without calculation.

A point of contact between two conductors may be determined with the arrangement shown in Figure 20.13b. Using a third-non-faulted conductor of the same diameter as the faulted pair, the additional resistance introduced by the contact is eliminated from the balancing circuit of the bridge by connecting it with the battery circuit, where it will not affect the result of the measurement, provided it is not so great that the current is too small for satisfactory operation of the instrument.

As is seen from the diagram, with equal resistances in arms A and B and with the bridge in balance, the resistance of the non-faulted third conductor $R_L$ plus the resistance of one of the connecting conductors from the far end to the fault ($R_L - R_x$) is equal to the resistance of one conductor from the fault to the instrument plus the resistance $R_r$. In other words,

$$R_L + (R_L - R_x) = R_x + R_r, \quad \text{or} \quad R_x = \frac{2R_L - R_r}{2}.$$

In practice, in locating a fault by this method it is necessary to use the bridge method with a fixed ratio of the two arms as described above and to measure the loop resistance of a pair consisting of one non-faulted (third) conductor and one faulted conductor connected at their far ends. The value of the loop resistance of the conductors from the instrument to the fault may then be obtained by subtracting the value of resistance indicated by the bridge from the value of the resistance for the entire loop.

The bridge method of measuring with a variable arm ratio is similar in principle to the method with a fixed arm ratio, the only difference being that instead of establishing the bridge arms so that A equals B and using a variable resistor to compensate the difference between the resistances of the non-faulted conductor and the faulted conductor, arm B is completely eliminated and variable resistor $R_r$ is connected in its place, as shown in Figure 20.14. With such an arrangement the ratio of $R_r$ to A is equal to the ratio of the resistance of the faulted conductor from the instrument to the fault to the resistance of this conductor from the fault to the far end plus the resistance of the non-faulted conductor. Mathematically this may be expressed as

$$\frac{R_r}{A} = \frac{L - l}{L + l},$$

assuming the diameters and material of the non-faulted and faulted conductors are the same.

Example 20.6. In Figure 20.14 the resistance of the arm is 1,000 ohms and the bridge is balanced with resistor $R_r$ at 634 ohms. Determine the distance to the fault in the insulation, both conductors having equal resistance and a length of 65 km.

$$\frac{634}{1,000} = \frac{65 - l}{65 + l} \quad \text{or } 634\ (65 + l) = 1,000\ (65 - l)$$

or $1,634\, l = 23,790$;

hence, $l = 14,56$ km.

There are several other methods of measurement employing the bridge to locate a fault, but they are more complicated.

In all practical cases it is necessary to consider the correction for temperature, the effect of loading coils (where such coils are used), and the effect of the lead wires to the instrument when the length of the cable which is to be measured is short.

## 20.4. Measuring Ground Resistance and Checking the Firing Voltage of Arresters

In addition to conductor measurements, the condition of grounds at cable and pilot poles is checked by resistance measurements. Ground-resistance measurements are often performed by the three-sum method. This method of measurement and calculation is the same as that already described in this chapter for measurement of three conductors. In this case it is necessary to have three grounds, two of which may be temporarily established for the measurements. In order to avoid error it is necessary to perform the measurements with an a-c generator connected instead of the d-c supply.

The IZ-48 meter produced by plants of the Ministry of Communications is available for ground-resistance measurement. This instrument permits direct reading of the resistance under measurement.

Testing of RA-350 gas-filled arresters is performed for the purpose of determining the voltage at which discharge occurs across the arrester. The tests are performed with an IGR-47 [gas-filled tester] having a generator and boosting the voltage of an autotransformer. By increasing the voltage at the output of the instrument the voltage at which the arrester begins to glow is established. If the glow does not begin until the voltage is above 350 + 40 v, the arrester is unsatisfactory and must be replaced, for the voltage on the conductor to which the arrester is connected may reach a level endangering the lives of the service personnel.

## 20.5. Fault Locator (IP)

The IP instrument serves to determine the direction of a fault of an overhead circuit (conductor) and the approximate distance to the circuit fault from any pole of the line without cutting the conductors under test. The IP instrument locates the following faults: shorts in the conductors of telephone circuits, contact with the ground of a telephone circuit (telegraph conductor), breaks in conductors, contact between telephone circuits (telegraph conductors).

In addition, the IP instrument may be used as a telephone. The basic diagram of the IP-47 instrument is given in Figure 20.19 and of the IP-50 instrument in Figure 20.20.

The IP-47 instrument consists of a magneto Ind with an interrupter, a switch K with three positions, a search coil KI, a transformer T, a telephone, a capacitor C, a 12-volt lamp of the switchboard type, and a 1.5-volt battery.

Before proceeding to determine the location of the fault the line supervisor connects the fault locator by means of line cords $L_1$ and $L_2$ (Figure 20.15) to an auxiliary or free circuit. Switch K of the instrument is set at position P (speech).

By turning the magneto handle the station is rung along the circuit consisting of: the winding of magneto Ind, contact 9, capacitor C, line $L_1$, the station or another telephone connected in the circuit, line $L_2$, contact 7 of switch K, the other end of the magneto winding.

During conversation the telephone transmitter is fed through the circuit consisting of: the battery contact, contact 1 of switch K, primary winding of transformer T, transmitter M, and the battery. The pulsating current arising in this circuit during speech is converted by transformer T to an alternating speech current which flows along the circuit consisting of: the secondary winding of transformer T, contact 10, capacitor C, line $L_1$, the station or another telephone, line $L_2$, contacts 4 and 6 of switch K, telephone receiver T, the secondary winding of transformer T.

When the line supervisor has received information concerning the nature of the fault and learns that the faulted circuit is ready for testing, he disconnects the fault locator from the auxiliary circuit, connects it with cords $L_1$ and $L_2$ to the faulted circuit and proceeds to determine the direction of the fault.

The principle of operation of the instrument as a fault locator consists in the following. Upon turning the handle of the magneto, capacitor C becomes charged and then discharges into the line. The periodic charging and discharging of the capacitor is determined by the position of an eccentric interrupter on the magneto shaft. While the capacitor is charging the contacts of the interrupter are open, and during discharge they are closed. A search coil with a telephone receiver connected to it is used in determining the direction in which the discharge current of the capacitor flows from the fault locator (that is, the direction of the short circuit).

The search coil consists of a steel core (which is placed over the line conductor) and a winding with its turns parallel to the conductor. If a pulse of current flows in the conductor over

which the coil is placed, the magnetic field formed around the conductor excites an emf in the turns of the coil, and through the telephone receiver connected to the coil there flows a current, with the result that a crackling sound is heard in the receiver. The fault-locator circuit is completed by setting switch K at position I (Figure 20.15). This forms the circuit for charging the capacitor from the magneto and discharging it through the shorted line under test as shown in Figure 20.16.

As the voltage of the magneto rises to its maximum (peak) value with contact 11 of the interrupter open, the capacitor is charged along the circuit consisting of: the magneto winding, contact 9 of the magneto, capacitor C, line $L_1$, the shorted point of the circuit, line $L_2$, contact 7 of switch K, the magneto winding.

With the maximum value of magneto voltage, when the capacitor receives its peak charge, contact 11 is closed by the eccentric, whereupon the capacitor discharges into the line along the circuit consisting of: the capacitor plate, line $L_1$, the shorted point of the circuit, line $L_2$, contact 7 of switch K, contact 11 of the interrupter, contact 2 of switch K, the capacitor plate.

The emf generated in the search coil causes a current which flows along the circuit consisting of: the coil winding, the telephone receiver, contacts 6 and 3 of switch K, the winding of the search coil.

The induced current flowing through the telephone receiver causes a characteristic sharp crackle in the receiver.

The test sequence for a faulted circuit is as follows.

When the conductors of a telephone circuit are shorted the section supervisor from the line must request the technical personnel of stations A and B to "complete isolation" of the faulted circuit for 2-3 minutes. The supervisor connects the line cords of the fault locator to the conductors of the faulted circuit, first cleaning the oxidation coating from the point of connection. Then he hangs the search coil KI on one of the conductors of the circuit 15-20 cm to the left of the line-cord clamp, that is, on the side facing station A (Figure 20.17), sets the switch at position I, and, turning the magneto handle, listens with the receiver. If crackle is not heard in the receiver, the circuit is not faulted in the direction of station A.

Then the search coil is moved and hung on the conductor to the right of the line clamp, that is, in the direction of station B. As before, the key is set at position I and, turning the magneto handle, the receiver is again used to listen for crackle. The presence of crackle in the receiver confirms that the circuit is faulted in the direction of station B.

The supervisor determines the approximate distance to the point of contact of the conductors by setting the switch at position L and, turning the magneto handle, watching the glow of the lamp (Figure 20.15). The glow of the lamp is due to the magneto current flowing along the circuit consisting of: the magneto winding, contact 9, capacitor C, line $L_1$, the point of the short on the line, line $L_2$, resistor R (shunting receiver T), lamp L, the magneto winding. The distance to the fault may be approximately established from the glow of the lamp.

With a break in one conductor on a telephone circuit the section inspector from the line must request the technical personnel to "complete the short" along the faulted conductor for 2-3 minutes at the same time at both stations (A and B).

The test with the IP instrument is conducted in the same sequence as above. If, upon placing the search coil on the conductor to the left of the point of connection of the instrument, crackle is heard in the receiver, this will indicate that there is no fault in the circuit in the direction of station A (Figure 20.18).

The search coil is then hung to the right of the line cord, that is, in the direction of station B. The switch is left in the same position 1. Turning the magneto handle, the receiver is again used to listen for crackle. The absence of crackle in the receiver confirms that the break is located in the direction of station B.

In addition to this method, the test may be performed by sending a ring from the line, in this case using the IP instrument as a portable telephone. With a break in a conductor of the telephone circuit there will be no ring at the station on the side of the break.

When the conductors of two telephone circuits are in contact one of them (the less important) must be isolated at both ends of the station and the other left for operation.

It is the duty of the line supervisor to ascertain which of the conductors of circuits H and M(Figure 20.19) are in contact and then to determine the direction of the fault relative to his position.

Which of the conductors of the circuits are in contact is determined in the following manner. A line cord of the fault locator is connected to one of the conductors of the isolated circuit, the switch is set at position L (Figure 20.19), the second line cord is alternately connected to the conductors of the other circuit and, turning the magneto handle, the lamp is checked for glow (Figure 20.19a). If the lamp does not light up, the line cord must be changed from the first conductor of the isolated circuit to the second conductor and the second line cord must again be alternately connected to the conductors of the other circuit until the lamp lights up. This will indicate that the given conductors are in contact.

Moreover, the approximate distance to the fault may be judged from the glow of the lamp.

When it has been ascertained which of the conductors are in contact, the direction of the fault from the site of the test is determined by the previously described method (Figure 20.19b).

The IP-50 instrument operates in the following manner (Figure 20.20):

a. In ringing the station, switch IT-PA (toggle) is set at the TA position and the magneto handle is turned. The magneto current flows along the circuit consisting of: contact 5, line $L_1$, the switchboard or another telephone connected to the line, line $L_2$, shunting contact ShK, contact 3-4, the switch, the magneto.

b. In the passage of a call from the line or from the station the ringing current flows along the circuit consisting of: line $L_1$, contact 4-5, the bell Z, line $L_2$.

c. During speech the speech button is depressed and the telephone transmitter M is placed in the circuit. The pulsating speech current flowing through winding AT of the autotransformer creates a magnetic flux in its core, with the result that an emf is induced in winding BP and the speech current flows along the circuit consisting of: end B of the autotransformer, contact 4-5 of the magneto, line $L_1$, the station or another telephone, line $L_2$, the 0.3-microfarad capacitor, the 0.2-microfarad capacitor, end P of the autotransformer. This speech is not heard in the receiver.

d. In listening to speech incoming from the line the current flow is the same as during speech.

The search coil for the IP-50 instrument is provided with a separate telephone receiver. The distance to the location of the fault is determined with the IP-50 fault locator in the same manner as with the IP-47 fault locator except that, instead of the switch, the IP-TA toggle is set at the IP position.

In determining the approximate distance to a point of contact between conductors the IP-TA toggle is set at the TA position. Turning the magneto handle, the pushbutton of shunting contact ShK is depressed and the glow intensity of lamp SL is observed.

The fault locator must always be kept clean and in good working condition. The instrument must be stored in a dry place. If moisture penetrates the instrument, it is necessary to dry it at a temperature not higher than 40° C. The battery must be removed from the instrument during the drying process. The instrument must be kept covered unless in use for testing or for

telephone conversation. The switch of the IP-47 instrument must be left in position L or I in order that the battery energy will not be wasted. The instrument may be disassembled only by supervisors familiar with its circuit.

## SECTION V. OPERATION OF LINE AND CABLE COMMUNICATIONS

### CHAPTER 21. ORGANIZATION OF THE OPERATIONAL AND TECHNICAL SERVICING OF LINE AND CABLE INSTALLATIONS OF INTERCITY TELEGRAPH AND TELEPHONE COMMUNICATIONS

#### 21.1. Organization of Line Service

The main task in the organization of line service is maintaining line installations in constant working order, thereby insuring uninterrupted operation of intercity telegraph and telephone communications under any meteorological conditions. This is achieved by technical inspection of line installations, systematic execution of preventive repairs, timely elimination of faults on communications lines, and the regular performance of repair work.

For the operational and technical servicing of intercity overhead communications lines (of class I and class II) within the oblasts and krays of the republics line technical units (LTU's) are organized and subordinated to the oblast (kray) and republic communications administrations. The organizational scope of the LTU's includes overhead lines of intercity telegraph and telephone communications from 1,000 to 2,000 km in length (including all cable entrances and inserts existing on the lines), overhead junction lines and cable junction lines between telegraph centers and intercity telephone exchanges at oblast, kray, and republic centers,

and also between the latter and radio centers. Also within the scope of the LTU's are conductors of the Ministry of Communications strung on poles of the Ministry of Railways and other departments.

According to the overall extent of line conductors, LTU's are divided into four classes: extra-class units, servicing from 7,500 to 15,000 km of intercity telegraph and telephone communications conductors, of which not less than 3,000 km are nonferrous conductors; class I units, servicing from 7,500 to 15,000 km of conductors; class II units, servicing from 4,500 to 7,500 km; and class III units, servicing from 2,000 to 4,500 km.

The line technical units are provided with the transport facilities, machinery, instruments, tools, materials, and implements necessary for operations in repairing and maintaining line and cable installations.

On the communications routes serviced by the LTU's line sections (LU's) are established. The extent of the line sections depends on the importance of the intercity communications line and on the average is as follows: on the main trunks of telegraph and telephone communications, 150 km; on trunk lines of communications, 200 km; and on intra-oblast lines, 260 km.

Within the makeup of the LU's are sections of line (sectional) supervisors (NDT's) which are directly subordinate to the line section chief (LUN). The average extent of the NDT sections is as follows: on the main trunks of telegraph and telephone communications, 15 km; on trunk lines of communications, 23 km; and on intra-oblast lines, 30 km. These figures vary according to the climatic and topographic conditions of the locality through which

the lines pass. If the communications lines pass through regions of severe icing, taiga, high mountains, or swamps, the NDT and LUN sections may be decreased by 20 percent.

Where a section has communications lines running parallel, the extent of the LUN and NDT sections is decreased (with two parallel lines the extent is decreased by 10 percent and with three parallel lines by 20 percent, depending on the number of conductors strung on these lines).

If line conductors of the Ministry of Communications are strung on poles of the Ministry of Railways or other departments (repair of which is performed by the owners of the lines) and if there are no parallel lines of the Ministry of Communications, the extent of the sections is increased by 40 percent for the LUN's and by 25 percent for the NDT's.

In determining the extent of sections on which there are cable inserts, one kilometer of cable (regardless of its capacity and the number of cable cases and vaults) is equated with one kilometer of overhead line.

For labor-consuming operations in preparing and hauling poles, repairing line installations, replacing conductors, clearing the right of way, and also for restoration operations on lines of communications in each line section (with the exception of the main trunks of telegraph and telephone communications) the duties of skilled staff workers are prescribed, allowing one worker for each 75 km of line and one worker for each 1,000 km of conductor. On line sections of the main trunks of telegraph and telephone communications, in order to insure intensified operational and

technical servicing of line installations, emergency restoration brigades (AVB's) composed of eight workers in non-icing areas and ten workers in icing areas and led by a technician of the line section are organized.

The staff workers [ShR in Figure 21.1] in line sections as well as the NDT's are directly subordinate to the chief of the line section and are assigned along the line in such a way that they may be quickly assembled for restoration operations in case of emergency on the line.

Along communications lines passing through sparsely populated, taiga, and wilderness areas of the North a staff worker is often assigned at each point where there is an NDT so that during unfavorable weather conditions in winter the latter can inspect the line with a companion.

At line technical units at the oblast, kray, and republic centers supervisors of emergency service are organized in round-the-clock shifts. These supervisors maintain constant contact with the technical personnel at the distributing frames of the oblast intercity telephone exchanges and telegraph centers and in case of disturbance of communications they test the circuits and conductors from the test poles nearest to the exchanges and upon the instruction of the LTU chief go out on the line to assist the section supervisors in restoring communications as soon as possible.

The scheme of the organization of line service on intercity telegraph and telephone communications lines is shown in Figure 21.1.

Constant control of the technical condition and the quality of servicing of line and cable installations of trunk telegraph and telephone communications by the Ministry of Communications is maintained by trunk line engineer-instructors to whom the individual management of trunk lines with an extent of 2,000-3,000 km is assigned.

## 21.2. Organization of Cable Service

Where overhead communications lines have cable inserts of considerable extent (for example, in city sections, at right crossings, in crossing electric railroads, etc) and in consideration of the specific requirements for servicing cable installations, the composition of line technical units includes separate cable sections (KU) -- one section for each 150 km of cable. For the maintenance of cable installations the cable sections assign a supervisor-solderer for each 25 km of cable run, including line facilities and equipments (cable vaults, cabinets and cases, cable boxes, cast iron sleeves, surveying markers, underground conduits with inspection shafts or boxes, guard signs or signal markers at cable crossings on rivers with shipping or barge transport, devices protecting the lead sheathing of cable against electrical corrosion).

In individual oblasts, krays, or republics where there are four or five cable sections within an LTU (depending on the importance of the intercity cable lines which are to be serviced) and where it is necessary to improve the management of the cable sections, intercity cable units (MKU's) are created which are subordinate to the oblast or kray communications administrations.

For the operational-technical maintenance of trunk cable communications lines of great extent joining Moscow with the main telegraph and telephone communications units on the union level and also with the republic and large industrial centers, administrations of technical operation of cable telegraph-telephone trunks (UKM) are organized which are directly subordinate to the All-Union Ministry of Communications. The administrative scope of the UKM's extends to cable lines of intercity telegraph and telephone communications with an overall extent of up to 3,000 km with all the associated cable and exchange installations.

Within the administrations of cable trunks and for each 500 km of cable run there are organized districts of technical operation of telegraph and telephone cable trunks (RKM's), which in turn are divided into sections (for 130-150 km of cable run) known as cable sections (KU's). Within the cable sections, there are assigned supervisor-solderers under whom sections of cable run not less than 25 km long are maintained.

At each RKM there is a group for electrical measurements and protection of the cable against corrosion. This group performs scheduled cable maintenance measurements, comparing these measurements with the data on the rating sheets for the line installations and communications channels, and locates cable faults. Each RKM also includes a repair and restoration brigade which performs repair and restoration operations, maintains the signal devices which warn of faulty cable insulation and reduced air pressure within cables, performs measurements to determine the strength of stray currents and the appearance of anodic areas along the cable run, and takes the necessary steps to protect the cables against the harmful effects of stray currents and ground corrosion. Within

each RKM there is also a group for marking off and supervising digging operations. This group coordinates and authorizes the digging operations of outside organizations within the protected zone of cable lines and checks on their progress.

## 21.3. Line Service Equipment

Overhead lines often pass through sparsely populated areas where the distances between isolated settlements are considerable.

In order to insure uniform spacing of section supervisors in such areas repairman homes are built alon the line and for the line sections and line technical units auxiliary buildings with supply yards are constructed. Along communications lines in the sparsely populated taiga areas of the North, between repairman homes there are additional winter houses where the supervisors may rest when out on the line.

Since the repairman homes are the fixed residences of section supervisors, stationary telephones are installed there for round-the-clock communication with nearby repeater points or test points and storerooms are provided for instruments, tools, and operational reserves of line materials.

For the maintenance of line installations each section supervisor must have a portable telephone of the UNAI or TAI-43 type with an attachment for locating faults or a special fault locator, a pocket volt-milliammeter, climbers, a repairman belt with an insulated strap and a repair kit with a set of tools. The tools consist of pliers 200 mm long for work with steel conductors, pliers with copper inserts for work with nonferrous



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

conductors, a trihedral soldering iron, a screwdriver, a drill with a diameter of 16 mm and length 360 mm, small-three-pulley blocks with a diameter of 40 mm and parallel grips, and 15-20 m of rope 8 mm in diameter. All these tools are required for the elimination of faults.

For preventive maintenance on the section the supervisor must have pliers 200 mm long, a hack knife, a hook wrench 300 mm long and 18 mm in diameter, an adjustable bolt wrench 300 mm long, a forked holder for joining nonferrous conductors by the sleeve method, tongs for thermite muffle welding of conductors, protective goggles, a screw auger 16 mm in diameter and 300 mm long, a vise, a hand saw, a sapper's axe with a 125-mm cutting edge, a shovel, a small crowbar for tightening straps, and an instrument for cleaning insulators. According to the nature of the work to be performed, the supervisor carries the necessary tools with him.

For the elimination of faults and the performance of preventive maintenance and repair operations on the sections at each NDT point there is created the following emergency and operational reserve of basic line materials: 200 m of field cable, 15 kg of steel line wire, 1 kg of galvanized tie wire, 10 kg of copper line wire (where copper circuits are in use), 0.5 kg of copper tie wire, 10 kg of wire rope for straps, 10 insulators. These reserve materials must be replaced as they are used. In addition to the above materials, each NDT point must have the following in reserve: 5 hooks, 2 pins, sufficient packing material for installing 10-15 insulators, 4 line grips, a set of thermite cartridges with fuses (50 per box) for each diameter of conductor on the line, and 4 copper sleeves for each diameter of nonferrous conductor.

For work on communications lines having crossings with or running parallel and close to lighting conductors and high-voltage transmission lines the NDT is provided with insulating gloves and rubber overshoes.

On trips for restoration operations and for the elimination of breakdowns on communications lines, upon presentation of standard travel papers the communications code entitles sections supervisors to unhindered passage on all passenger and freight trains, busses, and ships, as well as on individual locomotives and rail cars in places suitable for inspection of lines. Materials and tools will be transported free of charge. For movement along the line the supervisors are provide with skis in winter and bicycles in summer. For most rapid location and elimination of faults on the line at night the NDT is issued a flashlight.

For transport of line materials, implements, and property of the repair column each line section has one or two horses. Emergency restoration brigades on main trunks passing along highways are equipped with GAZ-51 trucks and, lacking improved roads, with the GAZ-63 trucks with increased ability to move over difficult terrain. A permanent reserve of materials and tools as called for in the table of supplies for the emergency restoration brigades (AVB's) is kept in the AVB trucks. These trucks are also equipped with revolvable lights for inspection of conductors at night.

For hauling of poles and other materials the line technical units are provided with ZIS-5 and GAZ-51 trucks and trailers, and for emergency engineering trips they are provided with GAZ-69 trucks.

In procuring poles in forest regions the line technical units use DT-54 or S-80 tractors and KT-12 skid tractors. For mechanization of heavy work in digging holes and raising poles during line repairs the line technical units are equipped with combination derricks and pole-hole diggers. In raising poles in line sections use is also made of hand winches. For finishing poles at storage points (roofing, drilling holes for hooks, cutting gains for cross-arms, etc) the line technical units are equipped with portable power units with a set of power tools (saw, drill, plane). The section supervisors and line workers are issued work clothes for wear during repair work and in maintenance work on line and cable installations.

21.4. Auxiliary Communications

The purpose of auxiliary communications. In order to insure clear and reliable operation of line and exchange services auxiliary communications are organized for test points and amplifying (relay) points, MTS's [intercity telephone exchanges] and telegraph centers, as well as for line technical units with technical personnel located along the run of an intercity line -- section supervisors, chiefs of line sections.

Arrangement of auxiliary communications on separate circuits. All NDT and LUN points along a repeater section are included in steel circuits set aside for auxiliary communications. In the absence of selector equipment, wall telephones with MB [local battery] supply are installed in parallel. The bells in these telephones have a high-impedance winding (2,000 ohms), hence with parallel connection of several phones excellent audibility and normal passage of ringing signals are obtained.

If more than five or six telephones are connected in parallel in an auxiliary communications circuit, it is recommended that at the NDT point in the middle of the repeater section this circuit be broken and separate telephones be installed at each end of the break. In case it is necessary to reconnect the circuit at this point an appropriate switch is installed.

As a rule, telephones are connected to the auxiliary communications circuit through transformers. In this arrangement the telephone need be connected only to half of the primary (exchange-side) winding of the transformer. With the use of transformers the attenuation of ringing and speech currents is considerably reduced (in comparison with direct connection of the telephones in the circuit) due to the high input impedance of the secondary (line-side) winding of the transformer. The arrangement of circuit entrances of auxiliary communications at NDT points is made according to the regulations for installation of subscriber entrances. Subscriber fuses are used as protective devices.

At an intercity telephone exchange or a repeater point the auxiliary communications circuits are connected to jack positions in the input switching equipment of the line control room.

Arrangement of auxiliary communications along separate conductors. In this case auxiliary communications are achieved with a single-wire circuit. If considerable interference from telegraph apparatus is observed, the auxiliary telephones are connected to the conductor through DK-0.1 filters. Since these filters do not pass the ringing (magneto) current, for transmission of ringing signals it is necessary to install special switches at the telephone positions. Thereby the filter is connected only during conversation; the rest of the time the telephone is connected to the conductor without the filter.

Arrangement of auxiliary communications without separate circuits and conductors. In the absence of separate circuits and conductors auxiliary communications with technical personnel is achieved along circuits of intra-oblast and intra-rayon communications. For this purpose at all NDT points telephones are connected with the local subexchanges. Conversations conducted in restoring communications are listed under the category of "communications emergency."

If the subexchange is not operated on a 24-hour basis, at the end of duty the telephone operator connects the NDT auxiliary telephone receiver in parallel with the circuit joining the substation with the rayon center. In such cases NDT is called at night by transmitting a prescribed number of rings.

## 21.5. Organization of the Work of Section Supervisors

In order to insure uninterrupted operation of telegraph and telephone communications by maintaining line installations in constant working condition and by timely execution of measures for the prevention of faults the section supervisor makes regular maintenance patrols of the communications lines within his section and performs minor repairs.

As a rule, maintenance patrols on main trunks of telegraph and telephone communications are made by section supervisors three times a week and on intercity lines (trunk and intra-oblast) twice a week. The supervisor patrols his section on foot and carefully checks the condition of line installations, eliminating defects he discovers along the line. In preparing the schedules for such

patrols consideration is given to the time of year and the travel conditions along the line, including the likelihood of faults and the volume of maintenance and repair work which the section supervisor is liable to perform.

In the spring after the snow has melted the supervisor makes a special patrol of his entire section for the purpose of collecting metal scrap which could be thrown against conductors and cause damage to communications. With the beginning of farming operations the section is patrolled more frequently in areas where tractors are used and movement of auto transport increases. Patrols must also be made more frequently during the harvest period.

On urban sections and in localities where any construction or loading and unloading operations are performed near communications lines the schedule calls for more frequent patrols. Wherever necessary the section supervisors must remain at work sites to insure that such work does not interfere with communications or cause line faults. For daily inspection of communications lines on urban sections in oblast, kray, and republic centers shift inspectors of the emergency service under the LTU are usually assigned to assist the section supervisors.

The section supervisors prepare the schedules of maintenance patrols on the basis of a six-day work week and an eight-hour work day. The time norms given in Table 21.1 are used in preparing the schedules.

The time required for returning from patrol is based on the average pedestrian rate of 4 km per hour.

TABLE 21.1

TIME NORMS FOR PATROL AND PREVENTIVE MAINTENANCE OF 1 KM OF LINE

| No of conductors on line | Time norm for patrol and inspection of 1 km of line (minutes) | Time norm for maintenance work on 1 km of line (minutes) |
|---|---|---|
| up to 8 conductors | 20 | 40 |
| up to 16 conductors | 25 | 70 |
| up to 24 conductors | 30 | 90 |
| more than 24 | 35 | 120 |

In Table 21.1 the time norms for preventive maintenance in replacing defective insulators and ties, cleaning insulators, replacing straps, straightening hooks and crossarms, adjusting conductors, straightening poles, and trimming trees are based on the volume of work given in Table 21.2.

The time which the section supervisor requires for patrolling the line and performing maintenance work is determined from the above norms.

Example 21.1. Let the length of intercity communications lines of class II within the section of a line supervisor be 25 km; 16 conductors are strung on the line. Determine the amount of time required by the supervisor for eight patrols of his section in performing the necessary maintenance work.

Solution. According to the norms given in Table 21.1, 25 minutes are required to patrol a kilometer of line with 16 conductors. Hence, the time spent in patrolling the entire section will be 25 min x 25 = 10 hr 25 min. In addition, in returning

from patrol (in the absence of transportation the supervisor walks one km in 15 min) the time spent is 15 x 25 = 375 min = 6 hr 15 min. Thus, the total time spent on one patrol is 10 hr 25 min + 6 hr 15 min = 16 hr 40 min, and on eight patrols 16 hr 40 min x 8 = 133 hr 20 min.

In preparing the patrol schedules supervisors of adjacent sections shall have different days of rest so that in case of a fault on the line of a supervisor on his day off the supervisors of the adjacent sections can quickly eliminate the fault.

Consideration must also be given to settlements along the run where the supervisor can find a night's lodging and to transportation facilities for the return trip to his place of permanent residence.

Where it is necessary to remain overnight at a settlement along the line, with the approval of the LUN, the section supervisor is given a quarters allowance. For rail travel rail tickets are issued or payment is made for bus travel within the limits of the section.

The section supervisor must be ready at any time of day to go out on the line in order to locate and eliminate a fault in the shortest possible time. Hence, even during his off-duty hours the supervisor must inform the chief of the line section and the technical personnel of the nearest repeater (test) point of his absence from the section. The section supervisor is given time off as compensation for work performed on the line during off-duty hours. In addition to the regular two-week vacation the line supervisor may be allowed leave in the amount of six working days

for work in excess of that called for under the norms. During prolonged absence of the section supervisor (detached service, vacation) an experienced staff worker is sent as a replacement to the NDT point on the trunk telegraph and telephone line.

TABLE 21.2

AVERAGE TIME REQUIRED FOR INDIVIDUAL OPERATIONS PERFORMED BY THE LINE SUPERVISOR WHILE ON MAINTENANCE PATROL

| Operation | No of operations to be performed | Average time per unit of work (minutes) | Frequency |
|---|---|---|---|
| Replace insulators | 1% of total No | 5 | once a year |
| Replace ties | 2% of total No | 4 | same |
| Clean insulators | 100% of total No | 1.5 | twice a year |
| Same, in vicinity of railroad stations and near factories and plants | 100% of total No | 1.5 | twice a month |
| Straightening hooks | 1% of total No | 5 | once a year |
| Adjusting 1 km of conductor | 1% of total extent | 60 | twice a year |
| Straightening poles | 1 pole per km | 40 | same |
| Replacing straps | 0.5% of total No | 20 | once a year |
| Straightening crossarms | 2 crossarms per km | 10 | twice a year |
| Trimming of branches per km of line | - | 60 | same |

On intra-oblast communications lines responsibility for servicing the section of a supervisor on vacation or detached service for not more than a month devolves upon the supervisors of the adjacent sections.

The condition of line installations and the quality of maintenance inspections over the section of a line supervisor are reguarly checked by the chief of the line section. Such checks are made once a month on trunk communications lines and once every two months on intra-oblast lines according to the schedule approved by the LTU chief.

In his technical inspection of the line installations the chief of the line section checks for defects on the line and ascertains their causes. He gives the section supervisor a specific assignment for completion of maintenance operations on the line and prescribes the time in which it is to be done. He enters the results of his inspection in the section supervisor's record. On his next inspection of the line installations the chief of the line section checks for completion of the assignment by the section supervisor.

The work done each day by the section supervisor is entered in the record and a monthly report of the work completed is presented to the chief of the line section.

For rapid elimination of random faults on the line in accordance with instructions during the maintenance inspection and execution of work on the line, the section supervisor maintains contact with the technical personnel of the nearby exchanges by connecting his phone to the line every 1-2 hours.

Upon disturbance of the operation of telegraph and telephone communications the section supervisor proceeds without dispute or delay to carry out the operational instructions of the exchange technical personnel of the communications enterprise in charge of the testing and restoration of the damaged communications.

During operation of a repair column on a section the supervisor of the latter takes part in the work as a member of the brigade or as an assistant and checks on the quality of the work to see that it is performed in accordance with the technical regulations and with strict observation of rules for safety in working with live conductors without permitting any interference or disturbance of communications operations. He maintains regular contact with the technical personnel of the nearest repeater points (UP's), telegraph centers, intercity telephone exchanges (MTS's), or test points (KP) and, as a rule, reports each day on the beginning and conclusion of repair operations on the section.

## 21.6. Preventive Maintenance on Communications Lines

The basic and deciding factor in insuring trouble-free operation of telegraph and telephone communications is the supervisors' precise and unfailing fulfillment of the requirements of the Instruktsii uchastkovomu nadsmotrshchiku mezhdugorodnykh telefonno-telegrafnykh liniy svyazi [Instructions for Section Supervisors of Intercity Telephone and Telegraph Communications] (Svyaz'izdat, 1949). Hence, each section supervisor must be well acquainted with and precisely and scrupulously perform his duties as outlined in the above instructions.

The work experience of advanced section supervisors who are the real masters of their work and have attained trouble-free operation of the communications lines in their sections over a long period of time shows that the secret of their success is their excellent knowledge of the condition of line installations, daily work along the section in discovering and eliminating conditions which may cause faults, and the timely adoption of measures for anticipating random faults.

For example, in order that faults will not be caused by objects falling on conductors the work of the section supervisor must not be limited to gathering metal objects along the line which may be flung onto the conductors. It is necessary to explain how these metal objects came to be where they are. If they are the ends of old ties or line wire, then it is necessary that during work on the section the repair column establish a procedure whereby each worker gives the brigade leader of the column the old ties and ends of wire in order that the line will not be fouled by them. On communications lines passing along railroads it is necessary to persuade the rail shops (through the LUN's and LTU's or the communications administration) to organize the collection of rail jumpers when replacing them and of the stove wire used for fastening snow shields, and also to use nonmetallic materials for this purpose.

In populated localities, at loading and unloading points, and in construction areas all homeowners and organizations conducting work near the protective zone of communications lines must be informed of the safety measures to be adopted in the execution of their work and must be personally warned by the section supervisor of their liability for violation of the Pravil ustroystva i okhrany liniy svyazi [Regulations for Installation and Protection of Communications Lines] (Svyaz'izdat, 1949).

At the same time the section supervisor systematically conducts explanatory work in the schools, in pioneer detachments, and among the people living along the communications lines. He tells them of the harm caused by damage done to communication lines



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

and to their protective arrangements. Not one case of damage to line installations is to go uninvestigated, for this is the socialist property of the state, and in all cases the guilty ones must be brought to account.

The work method of Ye. M. Lemin has found wide application in the work of the advanced section supervisors. Essentially this method consists in the fact that at the same time the preventive-maintenance inspections are being made over the entire section in accordance with the NDT schedule, systematic preventive repair of the line and conductors is being performed on one stage of the section. For this purpose the entire sections is divided into several stages of 15-20 poles each. During each preventive-maintenance inspection of the entire section the supervisor climbs each of the poles in a given stage and carefully checks the condition of the fastening of accessories and conductors and eliminates defects in the placement of insulators, tying of conductors, fastening of crossarms, brackets, pins, and hooks. At the same time he performs the regular cleaning of insulators.

Performance of work by the Lemin method permits the section supervisor to be well acquainted with the condition of line installations along his section and at the same time to discover and eliminate defects occurring on the line and thereby to prevent possible disturbances of telegraph and telephone communications.

The valuable work experience of advanced section supervisors in adopting special measures for the prevention of faults is also worthy of attention. Thus, to prevent breaking of insulators when conductors have a sharp bend in the horizontal plane the levelling of the lines is changed so that the conductors rest on the insulators and there is no upward stress on the ties on the

individual poles. In putting the insulators on the pins sulfur is used instead of cable filler. In order to prevent conductors from being broken by farm machines passing under communications lines arrangements are made with the MTS's [machine and tractor stations], sovkhozes, and kolkhozes along the line to designate particular points for passage and to increase the clearances at those points. In order to prevent trees from falling onto lines the right of way is increased. In order to prevent damage during construction operations near the protective zone of communications lines agreement is made with the organizations performing such work on a procedure which will insure uninterrupted operation of telegraph and telephone communications lines during the work. Section supervisors are present during the execution of any operations which may cause damage to the sections. It is very important that in the course of his duties the section supervisor deal personally with the individuals performing this work and instruct them so that damage will be avoided.

On sections serviced by inexperienced supervisors line faults often arise during bad weather from so-called "elemental causes" and the supervisors must go out into such weather (often at night) to eliminate the faults. The work experience of advanced supervisors attests that with good maintenance of line installations faults will not occur even under the most unfavorable weather conditions.

A study of the causes of line faults during hurricanes, icing, vibration of conductors, and spring flood shows that their real causes are defects in the condition of line installations which were not detected in time and eliminated by the line supervisor.

Thus, with a good knowledge of the condition of line installations on the section and with timely discovery and elimination of defects in the condition of line installations the line supervisor has every possibility of preventing any fault which may occur on intercity telegraph and telephone lines.

## 21.7. Preparing Line Installations for Winter Conditions

In order to insure trouble-free operation of telegraph and telephone communications lines under any unfavorable conditions during the fall-winter and winter-spring periods the line technical units adopt special measures in accordance with Instruktsiya o merakh po obespecheniyu bespereboynoy raboty telefonno-telegrafnykh svyazey pri obrazovanii na provodakh osadkov izmorozi i gololeda [Instructions on Measures for Trouble-Free Operation of Telephone and Telegraph Communications During the Formation of Hoarfrost and Ice Deposits on Conductors] (Svyaz'izdat, 1954). The section supervisor must be familiar with the requirements of these instructions and carry them out exactly.

In preparing for winter conditions it is of decisive importance that the weakest and most vulnerable points on the line be discovered during operation. Hence, all decaying poles must be replaced during the summer. During the same season work must be performed in adjusting and replacing old conductors as well as in detecting and replacing defective areas on conductors. This is especially important in areas where conductors are subject to vibration and where there are frequent cases of conductors wearing out through rubbing against insulators. Such defective sections may be discovered by the section supervisor while cleaning the insulators.

Where the supervisor's inspection of line installation shows it to be necessary the line is strengthened with anti-wind and reinforced poles.

The section supervisor also makes a careful check of all poles parallel with communications lines or high-voltage lines which in falling may damage the communications lines serviced by him.

In order to prevent breaking of conductors and falling of poles of other lines at crossings with intercity telegraph and telephone lines the section supervisor must conduct a regular careful inspection of all crossings, check the clearances for conformance with the norms, check the condition of poles and conductors at the crossings, and take the necessary steps to see that they are in accordance with the technical requirements.

In order to combat icing conditions on intercity telegraph and telephone lines, upon the request of the communications administration the oblast (or kray) executive committees approve the plan for mobilizing additional workers from the kolkhozes and local residents.

In accordance with these plans the line technical units contract with the kolkhozes for the formation of a work force and the provision of transportation facilities in order to carry out operations to combat icing. The emergency restoration brigades on main communications trunks are reinforced with workers assigned from the rayon communications offices. These workers remove the ice from conductors and perform restoration operations during disturbances of communications.

Wooden staves and wooden poles, the latter being 5-8 m long (bamboo, birch, or fir) are made and transported at NDT points in order to strike ice and hoarfrost from the conductors. Brooms are made for sweeping wet snow from crossarms. Machines and attachments for removing ice from conductors are readied.

With the appearance of ice deposits the section supervisor must quickly inform the chief of the line section and the MTS or UP technician and quickly organize removal of the deposits.

Removal of ice deposits must be achieved on all conductors. Removal of hoarfrost or rime is necessary only on nonferrous conductors with high-frequency carrier transmission.

Ice or hoarfrost is removed from conductors by means of a strip of wood (a scraper) fastened onto the end of a light pole, or the conductors are struck lightly with the pole beginning at the point of suspension of the conductor. The poles are carried between the conductors in the vertical position. The conductors must not be struck so that they come in contact with one another. Ice or hoarfrost deposits may be removed from conductors by the use of pneumatic hammers operated from compressor units or containers of compressed air.

Rime may be removed from the conductors by striking them with wooden staves at the pole.

As the snow begins to melt flood preparations are made and the following steps are taken:

on the basis of the experience of previous years the condition of the line at all danger spots along the route of the ice breaker and the spring waters is inspected;

the necessary materials, tools, and implements are readied and transported to the points of possible breakdown;

at overhead crossings of rivers standby crossings are made by laying PRVPM cable and stringing conductors on other poles;

at cable crossings of rivers the ice is chopped away at the shore ends of the cable and the condition of the shore fastenings of the cable is checked;

at especially important points emergency restoration brigades are organized on a round-the-clock basis and the brigades are equipped with the necessary materials, tools, and boats; temporary telephone communications are established with the brigades.

Wherever necessary special work is performed to reinforce line installations in the path of the ice flow and flood.

Well-executed precautionary measures are guarantees of trouble-free communications during unfavorable weather conditions.

## 21.8. The Location of Faults and the Procedure for Eliminating Them

In the testing of conductors a special terminology has been established which enables the exchange and line technical personnel to understand readings and realize what must be done without superfluous explanations. A few of the most frequently used expressions are given below.

To "complete isolation" or to "isolate a conductor" means to disconnect (separate) the conductors at a specified point (at an exchange, a test pole, or a cable case). The disconnected ends of the conductors must not come in contact with other conductors or with surrounding objects.

To "complete ground" or to "ground a conductor" means to connect a given conductor with ground at a required point (in a cable case or at a test pole). For this purpose the conductor under test must be connected with a ground wire.

To "complete a short with ground" (a grounded loop) is to connect the conductors of a circuit by means of a jumper and then to connect them with a ground wire.

"Isolation completed" indicates that there are no stray currents along a conductor (that is, that there is no contact with other conductors or connections with ground on the section from the exchange conducting the test to the test point on the line where the isolation is provided).

"Ground completed" indicates that there is no break in the conductor in the section from the exchange to the test point on the line where the ground is provided.

To "set a conductor or circuit on the straightaway" means that, if the conductors are disconnected at a test pole, the test clamps are to be connected; if an exchange was connected to the conductor or circuit, it is necessary that the switchboard be manipulated so that the exchange is disconnected from the circuit; if this request refers to a sectional pole from which the conductor or circuit branches out in a loop at the exchange, then the conductors are joined at the sectional pole in such a way that the loop is disconnected.

The technical personnel of the exchange perform the tests to determine the nature and location of the fault.

The methods of locating faults depend on the type of measuring equipment at repeater points and MTS's, relay points, and telegraph centers. At the present time the impulse-tracer fault locator (IL) is much used on trunk lines with nonferrous circuits for determining the location of faults from the exchange. This instrument permits accurate location of faults -- conductor breaks, contact between conductors, grounding of conductors, ohmic asymmetry of circuits. In this case the section supervisor immediately proceeds to the assumed location of the fault and, without testing on the test poles, locates the fault and eliminates it.

The operating principle of the IL instrument consists in the transmission of current impulses over equal intervals of time. If, in traveling along the line, the impulses encounter a break, a short, or contact with ground, they are reflected from such points and return to the instrument at beginning of the line and are observed on the screen of the instrument's cathode-ray tube. Knowing the rate of propagation and the travel time of the impulses along the line, it is not difficult to determine the distance to the point of reflection of the impulses. Provision is made in the IL instrument for special "electrical scale markings" by means of which it is possible to measure the distance to a point of irregularity (a cable insert, a change in the spacing between conductors). By means of the IL instrument the locations of breaks, contacts, and grounds on copper conductors are determined within an accuracy of one kilometer on lines approximately 100 kilometers long.

On steel circuits or on trunks not equipped with IL instruments the distance to the fault is determined by electrical measurements made in the manner described earlier.

In locating faults directly on the line the supervisors use the fault locator (IP) described in Section IV, Chapter 20.

In order to locate faults on telegraph conductors in the absence of an IP instrument line supervisors use portable volt-milliammeters. If the fault is of the nature of an "interruption" or a "contact with ground," a battery voltage is applied to the faulted conductor between relay points. The line supervisor tests the conductors at the test poles by unfastening the test clamps and connecting one terminal of the milliammeter to the ground wire on the test pole and the other terminal to the faulted conductor.

That side of the conductor on which, upon connecting the milliammeter, the needle is seen to deflect will be the non-faulted side. The side of the conductor on which the milliammeter needle does not deflect or deflects but slightly will be the faulted side.

Restoration of damaged communications is conducted in strict accordance with the Instruktsiya o poryadke likvidatsii avariy na mezhdugorodnykh telefonno-telegrafnykh liniyakh svyazi i opoveshcheniya o prostoyakh svyazey [Instructions for Sequence of Operations in Eliminating Faults on Intercity Telephone and Telegraph Communications Lines and Announcements Concerning Communications Breakdowns] (Svyaz'izdat, 1950), wherein are defined the interrelations between exchange and line technical personnel in eliminating breakdowns. These instructions also establish the responsibility of technical personnel for the most rapid restoration of communications.

The mentioned instructions oblige the line supervisor to carry out all operational directions of the technical personnel

of the MTS's, UP's, relay points, KP's, and telegraph centers in testing circuits and conductors (completing "isolation," "shorts," "grounds") and in eliminating faults. He is also obliged in tracing a fault to connect his telephone to the auxiliary communications circuit or a circuit prescribed by the technical personnel of the UP (or relay point) at least once an hour for conversations with the latter personnel concerning the results of inspection of the line section and for instructions concerning further operations.

In cases where the technical personnel of an exchange have determined the location of a fault on the line and, upon arriving at the location, the supervisor cannot find it by inspecting the line, he uses a fault locator. When the supervisor has located the fault and eliminated it, he calls the exchange technicians of the nearest UP or MTS on the telephone circuits of either a test point or relay point or on the telegraph conductors of the telegraph center and informs them of the cause of the fault. After the fault on the line has been eliminated the exchange personnel perform electrical measurements of the circuits (conductors).

With the conclusion of operations in eliminating a fault and upon receiving verification from exchange technicians that the restored circuit (conductor) meets the prescribed specifications, the line supervisor receives authorization from an exchange technician to return from the line.

If test measurements show that the restored circuit (conductor) does not meet specifications, the fault is not considered to be eliminated until the electrical characteristics of the circuit (circuit) have been brought up to standards.

In the case of a fault where the line supervisor finds that he will need material and manual assistance, he quickly informs the technical personnel of the exchange as well as the LTUN or LUN of this need, indicating the amount of damage and the assistance required. Regardless of this, the supervisor must exercise initiative and take every step for the most rapid restoration of intercity telegraph and telephone communications.

## 21.9. Methods of Eliminating Line Faults

In order that communications may be restored in the shortest possible time, operations for the elimination of faults are divided into two stages: first, temporary communications are established, and then restoration operations are conducted to bring the line installations up to technical standards.

In eliminating faults priority in the establishment of temporary communications is given to trunk telephone circuits with high-frequency multiplexing, next in importance are trunk telegraph conductors, next are the circuits and conductors of intra-oblast communications, and then the remaining conductors strung on poles of intercity communications lines are restored.

The following methods are employed in the elimination of line faults. With breaks in the conductors temporary communications are first established by the use of field cable. The ends of the field cable are fastened to the insulator with a double loop and a simple knot. They are cleaned and joined to the line conductor with jointing wire or tie wire so that the conductors of the field cable are in firm contact with the line conductor, the latter having been cleaned in the area of connection with the field cable. After temporary communications have been established



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

on lines with hook suspension the conductors on two or three adjacent poles are unfastened and lowered from the poles. They are then drawn up with blocks so that the ends of the conductors touch one another. The ends of steel conductors are joined by thermite welding and of copper conductors by copper sleeves. It is permissible to join the conductors temporarily with line clamps and later to weld the steel conductors and join the copper conductors with sleeves within three days after eliminating the faults.

After joining the broken ends of the conductors they are again lifted to the poles, adjusted, and tied to the insulators.

If a break in a conductor can only be repaired with an insert, it is made with wire of the same diameter and material as the line conductor. After joining one end of the conductor with the insert in the prescribed manner, the other end of the conductor and the insert are drawn up with blocks so that the length of the insert is equal to the replaced section of the conductor, and these ends are joined in the same manner. The conductor is then lifted to the pole, adjusted, and tied.

The work of eliminating a break in a conductor must proceed with care in order not to cause temporary contact between conductors.

In eliminating contact between conductors due to incorrect sag they are first disengaged by shaking them by hand from the pole or with the use of a stave. The conductors on the adjacent poles are then untied and the sag is adjusted.

When there is contact of communications conductors at intersections with 127- and 220-v lighting circuits the sagging conductors

are adjusted only while wearing rubber shoes and rubber gloves and with observation of the safety rules. In the event of contact with power transmission lines the operations for elimination of the fault must be performed only after shutting off the power line. For this purpose the line supervisor must immediately contact the proprietor of the high-voltage line and request the presence of his representative at the location of the fault.

Objects which have fallen or been thrown onto conductors are also removed by shaking the conductors in such a way that the objects do not come into contact with other conductors. If removal of the object by this method proves difficult, then it is removed by means of a pole or a rope. The latter is fastened in a loop around the conductor and pulled from one line pole to the other. The object can then be removed from the conductor at the latter pole.

Where the breakdowns are due to fallen poles temporary communications are organized by raising the tops of the poles and placing them on frame horses or other supports so that the conductors do not touch the ground and are not in contact with one another.

In establishing temporary communications in the event of numerous breaks in conductors use is also made of field cable, PRVPM conductor, or flexible cable. If there is a shortage of these, temporary communications can be established by using the faulted conductors on lines which have lower priority for establishment of temporary communications. In this case wire is used which has come from poles at the point of the breakdown and it is placed on temporary supports. These supports may be pieces of timber placed on frame horses, railings, fences, nearby trees, etc.

In addition to this, bare conductors must be hung on insulators. Steel wire used for inserts in copper lines in establishing temporary communications must be of the same diameter as the copper conductor in order to avoid ohmic asymmetry. Steel-wire inserts longer than 10 km are not permitted. The length of inserts of field cable in a circuit of copper conductors must also not exceed 10 km, for the field cable introduces additional attenuation with the result that operation of high-frequency telephone equipment is disturbed.

If PRVPM cable with vinyl chloride insulation is used as an insert in a nonferrous circuit, then an individual cable with both conductors joined together is used for each line conductor. Twisted field cable must not be used for inserts in telephone circuits, for such inserts cause reflection of electrical energy, introduce considerably more attenuation in the circuit than untwisted conductors, and require the use of special coils for matching the resistance of the insert with the resistance of an overhead line at the point of the splice.

After the temporary restoration of communications new poles are erected to which the conductors are transferred from the fallen poles. In order to facilitate the work, the conductors are removed from one side of a fallen pole and before the erection of the new pole they are carried on rods or staves to the opposite side of the line so that the new pole can be erected between them.

In the absence of a sufficient number of poles for a second class line the lines may be temporarily restored by using one pole for every two planned spans and installing the missing poles later.

In the absence of new poles a line may be restored by resetting the broken poles or mounting them on attachments. In the event of numerous breaks steel conductors are joined by welding and copper conductors by sleeving.

Use of the above methods of eliminating faults and other, more advanced methods should insure the rapid restoration of communications.

The speed with which faults are eliminated on communications lines also depends to a large degree on the readiness of the servicing technical personnel for rapid departure for the line and the transportation facilities at their disposal.

In determining the time required for the elimination of faults the average rates of travel are the starting points of calculations: by motor vehicle, 25 km/hr, by bicycle; 10 km/hr; on skis, 8 km/hr; on foot, 4 km/hr. In traveling to the fault locations by bus or train the travel time is calculated from the timetables.

# CHAPTER 22. MAINTENANCE OF LINE INSTALLATIONS

## 22.1. Classification of Repairs

As with any installation, overhead communications lines deteriorate in the course of time -- poles decay, wires corrode, etc. Consequently, it is necessary to correct such natural wear by erecting new poles, installing new insulators, stringing new conductors, etc. Such work is known as repair work.

For the purpose of preserving the mechanical strength of line installations and maintaining the normal electrical

characteristics of circuits, which is necessary in insuring uninterrupted communications operation, two types of line repair are distinguished: maintenance (planned preventive work) and overhaul.

Maintenance of line installations is conducted in the process of operation by daily, planned, preventive (prophylactic), light work performed by the section supervisors and heavy work performed by repair columns composed of the staff workers of the line sections.

Among the preventive operations performed by each section supervisor on his section are: cleaning of insulators (not less than twice a year), with the replacement of defective ties and insulators; straightening and replacing hooks and crossarms; fastening brackets, pins, and straps; removing unsatisfactory joints and defective places on conductors; partial adjustment, welding, and sleeve-joining of conductors within isolated spans; straightening and reinforcing individual straight-run poles; placing fill dirt at the bottom of poles; replacing guard poles damaged by vehicles or lightning; replacing stub poles wherever necessary; bringing line clearances at crossings up to standards; cutting away brush and trimming trees; replacing protective devices, line-matching units, and tie wires at cable poles and entrances; restoring pole numbers; removing metal waste from the right of way; etc.

In those cases where the volume of the above operations is is great, in order to insure its timely completion the chief of the line section sends a staff worker to assist the NDT on a one-time basis in completing individual types of work.

The repair column performs the following maintenance operations: planned replacement of poles (up to 25 percent of the total number of poles on the section), reinforcement of poles with attachments (wooden, reinforced-concrete, and iron rail), impregnation of softwood poles; hauling and leveling of individual poles; straightening angle poles and straight-run poles, replacing above-ground and underground reinforcements; replacing towers and tower supports; replacing conductors at crossings which do not meet the prescribed requirements; replacing corroded conductors in the vicinity of railroad stations, chemical plants, etc; adjusting conductor sag over approximately 10 percent of the section; applying special ties in areas with conductor vibration; partial reinstallation and elimination of defects on cable inserts; bringing the electrical characteristics of circuits and conductors up to standard.

The numerical strength of the repair column depends on the volume of the above operations which must be performed and is determined by the chief of the line technical unit.

Overhaul operations are performed periodically according to the service life and condition of line installations in order to bring them up to their specific technical standards.

During overhaul heavy operations are performed which may not be performed during maintenance. These are such operations as: replacement of more than 25 percent of the poles on the section; replacement of towers; continual replacement of individual worn-out or defective conductors not meeting electrical specifications or not insuring trouble-free communications operation; straightening lines and offsetting them; rearranging the transposition

of telephone circuits; decreasing the distance between poles, changing the line profile; continuous replacement of accessories and adjustment of conductors; reinforcing lines with semi-anchor, anti-wind, and other special poles in order to increase the stability of telegraph and telephone communications lines; widening the right of way; restoring communications lines damaged by natural disturbances.

Overhauls are performed by specially formed repair columns comprising the emergency restoration brigades and staff workers within the line technical units. Where the volume of operations is extremely large these columns may be reinforced by seasonal workers. The latter are engaged chiefly in auxiliary work.

## 22.2. Organization of Repair Operations

Preparation for repair work in forest regions begins with the procurement of poles. This is done in the winter when there is less sap in the trees than at any other season. In selecting the trees it must be kept in mind that trees growing in moist soil not holding back water have wood of better quality than trees growing in swampy ground, in an open area, or in a sparse forest, for the last three groups are distinguished by knottiness and less density of wood.

The poles are transported along dirt roads before the thaw arrives and are piled at storage points along the line in such a way that the air may freely pass between the poles. In order to prevent rotting of the lowest layer of poles, they are placed on blocks. Poles received by the central supply post are also stored in piles.

Before the repair season begins the staff workers of the line section finish the poles at the storage point; that is, they remove the outer and inner bark, seal the tops, bore holes for hooks and bolts, cut gains for the crossarms, and impregnate the pole with antiseptics.

While the poles are being prepared at the line sections repair work is performed on the trucks, machines, tools, implements, winches, blocks, tents, beds, bedding, items of daily necessity, repairman belts, pole climbers, cant hooks, jennies, shovels, harnesses, and wagons. Items in short supply are replenished.

Before operations begin 10-15 daytime seminars are held for the line workers at the LTU for the study of regulations for performing line operations (replacing and reinforcing poles, adjusting and welding conductors) and practical demonstrations are given in advanced procedures and methods of performing these operations. At the seminars the workers study in detail the safety regulations for working on overhead lines and safety measures to be adopted in working with live wires.

With the approach of the repair season the intercity telephone exchanges and telegraph centers perform general pre-repair measurements of circuits and conductors to discover those sections which do not meet the prescribed electrical standards. On the basis of the results of these measurements the chiefs of the line sections show the causes for the departure of the electrical characteristics of the circuits and conductors from the standards and designate the operations which must be performed in repairing the line installations.

For precise determination of the amount of work to be performed during the repair season, as soon as the ground thaws in the spring the poles are inspected. In this inspection the poles are checked from top to bottom, including their underground and above-ground reinforcements (braces, guys, attachments, guard stubs). The condition of conductors and ties is checked for conformance with the technical requirements for crossings with other lines, etc.

Inspection of the poles in the spring is performed by the chief of the line section or his assistant in company with the supervisor of the section under inspection. For removal of fill dirt in searching for signs of pole decay staff workers are brought along.

The degree of decay of poles is determined by the use of a probe (a steel rod 10 mm in diameter, with a handle at one end and the other end pointed and with scale divisions). Before testing a pole with the probe, it is struck with a hammer. If the pole gives off a dull sound, this is taken as a sign of decay. A resounding sound indicates the absence of decay.

To check the decayed area of a pole it is necessary to remove the earth at the base to a depth of not less than 50 cm. Then, thrusting the probe into the pole at several points around the circumference, the depth of penetration is noted. Adding the obtained values for the depth of decay and dividing the total by the number of probings, the average value for the depth of decay is obtained. Multiplying this value by $2\pi$ (that is, by 6.28) and subtracting the result from the circumference of the pole, we obtain the circumference of the unaffected portion of the pole. If this circumference is equal to or less than the value given in Table 22.1, the pole is reinforced with an attachment or replaced with a new pole.

Example 22.1. Determine the degree of decay of a pole by means of a probe if the following values are obtained for depth of decay: at the first point, 2 cm; at the second point, 4 cm; at the third point, 3 cm.

Solution. To determine the average value of decay we add the given depths of decay and divide by the number of probings: $2 + 4 + 3 = 9$ cm; $9/3 = 3$ cm.

Let us now determine the decrease in the circumference of the healthy portion of the pole by multiplying the average value of decay by $2\pi$ : $3 \times 6.28 = 18.8$ cm. Now we subtract the result from the outer circumference of the pole. For example, the circumference of the pole at the time of its erection was 60 cm; consequently, the previous circumference has been reduced by 41.2 cm (60 - 18.8).

If the obtained result of 41.2 cm proves to be less than the minimum permissible pole circumference given in Table 22.1, then the pole must be reinforced (if its upper portion is still unaffected) or replaced (if its upper portion does not permit strong fastening of hooks, crossarms, and brackets).

During the spring inspection the section supervisor informs the chief of the line section of all defects observed by him in the course of his duty which must be eliminated in the next repair season.

The results of the inspection of the poles are entered in a special "inspection sheet" with the numbers of those poles which are to be replaced or reinforced with attachments or braces in the current year. Note is also made of the principal work which must be performed by the repair column in repairing conductors and accessories.

TABLE 22.1

MINIMUM PERMISSIBLE CIRCUMFERENCE OF POLES AT GROUND LEVEL

| Length of pole, m | No of conductors | Circumference of pole at ground level (cm) for lines of type with span length, m | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | O | | N | | U | | OU | |
| | | 62.5 | 50 | 50 | 40 | 50 | 40 | 40 | 35.7 |
| 6.5 | 4 | 27.0 | 25.0 | 31.5 | 29.5 | 35.0 | 32.5 | 36.9 | 34.5 |
| | 6 | 30.5 | 29.0 | 36.0 | 34.0 | 40.0 | 37.0 | 41.0 | 40.0 |
| | 12 | 38.0 | 36.0 | 45.0 | 42.0 | 50.0 | 47.0 | 52.0 | 50.0 |
| | 16 | 42.5 | 40.0 | 49.0 | 46.0 | 54.0 | 51.5 | 57.0 | 55.0 |
| | 24 | 48.5 | 45.0 | 56.5 | 53.0 | 63.5 | 59.0 | 65.0 | 63.0 |
| 7.5 | 6 | 32.5 | 31.0 | 38.0 | 35.5 | 43.0 | 40.0 | 44.5 | 42.5 |
| | 8 | 36.0 | 34.0 | 42.0 | 39.0 | 47.0 | 44.0 | 49.0 | 47.0 |
| | 12 | 41.0 | 39.0 | 48.0 | 44.5 | 54.0 | 50.0 | 56.0 | 53.5 |
| | 16 | 45.0 | 42.5 | 53.5 | 49.0 | 59.5 | 55.0 | 61.0 | 59.0 |
| | 24 | 52.0 | 48.5 | 60.0 | 56.5 | 68.0 | 63.0 | 70.0 | 67.0 |
| | 32 | 57.0 | 54.0 | 66.0 | 62.0 | 75.0 | 69.5 | 77.0 | 74.0 |
| 8.5 | 8 | 38.5 | 36.0 | 44.0 | 41.5 | 50.5 | 47.0 | 51.0 | 49.5 |
| | 12 | 44.0 | 41.0 | 50.5 | 47.5 | 57.5 | 53.5 | 59.0 | 56.5 |
| | 16 | 48.0 | 45.0 | 54.0 | 52.0 | 63.0 | 58.5 | 65.0 | 62.5 |
| | 24 | 55.5 | 51.5 | 63.5 | 60.0 | 72.5 | 67.0 | 74.0 | 71.0 |
| | 32 | 61.0 | 56.5 | 70.0 | 66.0 | 79.5 | 73.5 | 82.0 | 78.0 |
| | 40 | 65.5 | 61.5 | 75.5 | 71.0 | - | - | - | - |
| 11 | 18 | 55.0 | 51.5 | 65.0 | 60.0 | 73.0 | 67.0 | 75.0 | 72.5 |
| | 24 | 61.0 | 56.5 | 71.0 | 66.5 | 80.0 | 73.0 | 83.0 | 79.0 |
| | 32 | 67.0 | 62.0 | 78.5 | 73.0 | - | - | - | - |
| | 40 | 72.5 | 68.5 | 85.0 | 79.0 | - | - | - | - |

Note: For poles of deciduous wood the values in the table are decreased by 10 percent.

With the beginning of the repair season the column (consisting of staff workers and provided with the necessary line materials, tools, implements, and transport facilities) proceeds under the chief of the line section or his assistant to the execution of repair work on line installations in accordance with orders issued by the line technical unit. The makeup of the column is determined by the amount of repair work to be performed and is divided into pole workers (working with the conductors on the poles) and auxiliary workers (performing auxiliary operations in hauling poles, digging holes, raising poles, filling holes and tamping fill dirt, straightening poles, cutting bushes, etc).

In order to increase the productivity of labor of workers of the repair column the composition of the column is divided into groups, each of which is responsible for the performance of individual, definite repair operations. For example, one group digs holes for poles and braces which are to be replaced or reinforced, a second group rigs and erects poles and straightens or reinforces existing poles, a third group repairs conductors and accessories and numbers the poles. The work area must not extend over more than 1-2 km. The leader of the column (an LIN or an LUNP) and the section supervisor are responsible for the quality of the repair work and must remain with the groups performing the more difficult work, that is, with the second group (to guide operations in erecting poles and fastening conductors) and the third group (to guide operations involving defective circuits and to check the quality of work of the preceding groups).

With the introduction of the advanced work methods of section supervisors (independently performing in the daily servicing of line installations all the light operations for their repair) the volume of work to be performed by the repair column has been sharply reduced on communications lines. Instead of the organization of repair columns at each line section, this permits the organization of one or two combined repair columns attached to the line technical unit. A combined column with 12-15 persons in the course of the repair season performs the major work in replacing and reinforcing poles and the others engage in maintenance over 2-3 line sections at a time with an overall extent of 500-600 km. The combined repair column is provided with a truck for the transport of materials and workers, which reduces the time expended in traveling along the line by foot and considerably increases the tempo of repair operations on isolated line sections.

With a large volume of work in overhauling communications lines the heavy work of the combined columns is mechanized, for which purpose they are provided with a combination hydraulically-driven hole digger and derrick, a power unit with a set of power tools, and other facilities for mechanized operation.

When repair on one line section is achieved in the course of 1-1.5 months conditions are created for the attending technical personnel (the chiefs of the line sections and the section supervisors) to devote greater attention to the daily operational and technical servicing of line installations and the adoption of measures to insure trouble-free communications operation.

For the purpose of proper placement of the work force, on the evening before a given workday the leader of the column inspects the line section which is scheduled for repair and determines the amount of work called for in the "inspection sheet" and the amount of materials required.

At the conclusion of the workday the column leader lists the work done, indicating the compliance of individual workers with the prescribed work norms as well as the quality of their work, and gives the work assignment for the following day. Information on over-fulfilment of work norms is posted on the board for indexes of socialist competition.

While repair works is in progress on the section the column leader determines which poles are subject to replacement in the coming year, listing the pole numbers in a notebook and noting the work completed in the repair of line installations.

Upon concluding repair of the line, on the basis of these data a report is prepared on poles to be replaced or reinforced under the repair plan for the coming year. Precise determination of the volume of work called for in this report on poles to be replaced or reinforced is conducted each year, as mentioned above, during the spring inspection of poles.

The quality of the work performed in repairing line installations is checked by the line technical unit, which turns the repaired line sections over to the commission of the oblast communications administration. Upon receiving the repaired line sections the receiving commission evaluates the quality of the repair operations and determines the readiness of the lines for operation under winter conditions.

## 22.3. Repair of Poles

Straightening tilted poles. A pole may acquire rake due to unequal conductor pull on opposite sides and due to wind pressure on the pole and the conductors, especially if the ground is loose and inadequately tamped. In the majority of cases tilting of poles is observed in loose ground, with a large number of conductors, with inadequate application of fill dirt, with inadequate setting of braces, and with the absence of crosslogs in the ground at corner poles.

If the top of a pole on a straight run has gone out of line, a temporary guy is loop-fastened to the top (Figure 22.1) (if the temporary guy is fastened to the top above the conductors, the loop and the upper end of the guy are covered with a rubber sleeve). The earth is then removed to a depth of 50-75 cm on the side opposite the rake of the pole, the end of the guy is fastened to a stub pole and, drawing up the guy by means of blocks, the pole is straightened. A small degree of rake may be eliminated without the use of a guy by pressing with pike poles against the direction of tilt.

If the pole has moved from the vertical in the direction of the conductors, then the earth is removed in the direction in which the pole must be straightened, the conductor ties are loosened on the insulators, pike poles are pressed against the pole at the highest possible point, and it is thus brought to the vertical position. The open space at the butt of the pole is closely packed with stones, these are tamped, and fill earth is packed over them.

If a pole has moved from the vertical position due to loose ground, at a depth of 0.5 m on the side of the tilt a 1-meter length of log (from an old pole) is placed in the horizontal position.

In straightening a pole the conductors must not be permitted to swing, for this may cause whipping and give rise to interference ("surges" and "crackles") in communications channels, which hampers normal operations, especially of voice-frequency carrier telegraph.

Replacement of Poles. Poles are replaced only if they are decayed at the center or at the top (that is, where the accessories are fastened).

The length of the new poles must, as a rule, be the same as those to be replaced, while the diameter is as given in Tables 12.6 and 12.7. From the data of these tables it is seen that the diameter of the pole depends on the number of conductors strung on the line. However, it often happpends that additional conductors are strung on a line without replacing individual poles whose diameters do not conform to the norms. Replacement of such poles usually coincides with planned maintenance or overhaul operations. Hence, in carrying out repairs it is necessary to install new poles with diameters conforming to the above-mentioned norms.

The wide introduction of advanced methods employing the lightened LR-1 winch is of great importance in increasing the workers' productivity of labor. The following procedure is adopted in using this winch for replacement of poles installed directly in the ground on communications lines with hook suspension. A hole is dug in line with the old pole and preparations

are made for erection of the new pole. The winch is fastened to the old pole on the side away from the hole for the new pole and in a position convenient for manual cranking. The rope from the winch is fed through a block fastened at the top of the pole. The end of the rope is tied to the new pole at a point 1.5-2 m from the top. The butt of the new pole is placed against a bump board inserted in the hole. The pole is raised by turning the winch handle (Figure 22.2).

After raising the new pole the hole is filled with earth and tamped. The conductors are then freed from the old pole and fastened to the new pole. In order to prevent the old pole from falling a strap is used to fasten the top of the old pole to the top of the new pole. Work on the pole is made easier by rigging it with hooks while on the ground. If there is a shortage of hooks, they are removed from the old pole and transferred to the new pole. In order to lower the old pole the rope from the winch is fastened to its top and the winch and block are installed on the new pole. The old pole is sawed at ground level, the strap is freed at the top, and the pole is lowered to the ground by turning the winch handle. After this the rope is fastened to the butt of the sawed pole and it is drawn from the ground by means of the winch. The hole is filled and the earth tamped. In view of the fact that in replacing poles by this method the new pole is erected not on the spot of the old pole but next to it, in replacing this pole at a later year the new pole must be erected from the opposite side so that the span lengths will be in accordance with the norm limits.

If the new pole must be erected precisely on the spot of the old pole, the work is performed in the following sequence. The old pole is reinforced with two guys, the conductor ties are loosened, and the winch and the block (with the rope from the winch fed through it) are fastened in place. The hole is dug out, and the pole is sawed at the surface of the ground and shifted along the line onto a wooden block placed next to it. The rope is fastened to the butt of the pole and it is removed from the hole. Then the rope is tied to the top of the new pole and the pole is raised. After installing the new pole a temporary strap is fastened from its top to the top of the old pole and the conductors are transferred from the old pole to the new pole. The old pole is lowered to the ground by means of the winch in the manner described above.

On communications lines with crossarm suspension, in replacing poles with the use of the hand winch the new pole is placed next to the old pole and on the side facing the crossarm. This is done so that the crossarm may be released from the old pole and fastened to the new pole without unfastening the conductors. The procedure in replacing the pole is similar to that described above. Operations for replacement of poles on a straight run may be performed by a single supervisor with the use of the winch.

In the absence of a winch replacement on lines with hook suspension is performed in the following manner. The pole is secured with pike poles and jennies. A worker climbs the pole and, from the top downwards, unfastens the conductor ties on the insulators and transfers the conductors to insulators on light poles temporarily set up on each side of the old pole (Figure 22.3).

The earth around the bottom of the pole is dug out, with a wider part removed in the direction of the line. The pole is then turned through 90 degrees and carefully lowered to the ground by holding it with the pike poles and jennies. The hooks (with the insulators on them) are unscrewed. The old pole hole is cleaned of decayed wood and is again dug to the required depth. The new pole is placed in the vertical position and the butt of the pole is put in line with the other poles. The hooks are installed perpendicular to the direction of the line. The pole is then given the final alignment in both directions (along the line and perpendicular to it) with a plumb line. Fill earth is shoveled into the hole and carefully tamped in separate layers of 8-10 cm. In rocky ground hard lumps are mixed with sand or dirt and tamped. The fill dirt is built up to a cone around the base of the pole.

After the fill dirt is tamped a worker climbs the pole and from the top downwards carefully transfers the conductors from the side poles to the insulators on the line pole and, finally, ties the conductors with new pieces of tie wire.

In replacing poles on lines with crossarm suspension an attachment (Figure 22.4) is used to support the crossarm or use is made of light side poles which are tied with ropes to the end of the crossarm. After freeing the old pole from the crossarm the pole is lowered to the ground, as described above. Then the new pole is erected. The crossarm is removed from the ladder-type attachment or side poles and fastened to the new pole. Lowering of the old pole and raising of the new one may also be performed with the use of a winch fastened to the ladder.

In replacing a pole on the side of a hill the depth of the hole must be determined from its lowest edge.

Replacing Corner Poles. Corner poles must always be given the most careful inspection. Poles with the largest diameter are chosen for replacement of corner poles.

Corner poles are replaced in the following sequence of operations. The conductor ties on the adjacent poles are loosened. The next adjacent poles, on which the conductors are not unfastened and which are subject to strong pull in one direction, are temporarily reinforced with braces.

The pole which is to be replaced is reinforced at the top with one or two temporary guys, the lower ends of which are fastened with the use of blocks to temporary stub poles set in the ground for this purpose. The use of a crowbar (instead of the stub pole) driven into the ground and held by a worker is not permitted.

A hole is dug next to the pole and in line with the conductors.

After reinforcing the pole, it is climbed by a worker and the ties are loosened so that each conductor is held to its insulator by one or two turns of tie wire. The worker must always place himself on the side of the pole opposite the direction of conductor pull.

The new pole is erected next to the old pole so that it is raked in the direction opposite to the resultant pull of the conductors and its butt end is located within the vertex of the angle.

After the new pole is erected and reinforced the conductors are transferred from the old pole and fastened to the insulators.

The old pole is dug out, freed from its temporary guys and braces, and then removed from the hole. The rotted wood is removed from the hole and the hole is filled and the dirt tamped.

In replacing a decaying brace the pole is first reinforced with a temporary guy. The earth is dug from around the brace, it is freed of its fastenings with the pole, and it is lowered to the ground with care being exercised to avoid contacting the conductors. The rotted wood is removed from the hole and a new brace is installed with crosslogs.

At the top of the brace a carpenter cuts a hollow which must fit snugly against the pole. When the brace has been bolted to the pole no gaps must exist between the pole and the groove in the brace. Earth is shoveled into the hole and tamped, and the temporary guy is removed.

In replacing a guy or an anchor reinforcement the top of the pole is pulled back for an allowed slack by means of a temporary guy with blocks. If it should prove necessary, the conductors on the two adjacent poles are removed from their ties and the pole is dug out to a depth of 0.6 m on the side of the guy. After the new guy is installed the temporary one is removed. The guy must be drawn up tightly or it will not serve its purpose.

Reinforcing poles with wooden, rail, and reinforced-concrete attachments. Before digging the hole the pole is reinforced with pike poles. In reinforcing the poles with single attachments holes are first dug along the line for the attachments (the old hole is dug out) and at the place of insertion of the attachment the hole is widened according to the thickness of the attachment. Flat faces are then cut on the pole and on the new attachment.

In order to remove a decayed butt from a hole before installing the new attachment the butt is sawed half through from the side on which the attachment is to be installed. During the sawing the pole is tilted away from the side for the attachment. After the saw cut is made the attachment is put in place and the straps are put on and twisted through 1-2 turns with a small crowbar. The butt of the old pole is then sawed completely through by tilting the pole 5-10 degrees toward the attachment. The decayed butt is next removed and the straps are given the final tightening. The hole is then filled.

In reinforcing poles with double attachments the holes for the attachments or rails are dug out on both sides of the pole. Before digging the hole the pole is reinforced with pike poles. Flat faces are cut on both sides of the pole down to the butt. In reinforcing poles with double rail footings the pole is sawed at two places: at the surface of the ground and 30 cm above to a depth equal to the width of the saw. The rails are then placed in the hole and checked for close fit against the pole. The pole and rails are fastened with straps. The lower straps are placed on at the surface of the ground, then they are shifted to the lower portion of the butt where they are tightened with a crowbar. Then the above-ground straps are put in place and fastened. The wood between the previously made saw cuts is then chipped out. A saw is inserted into this space and the rest of the wood is cut out.

If the butt end of the pole is too decayed to permit its use as a filler block between the rails in the underground portion, reinforcement of the pole is achieved in the following manner. After reinforcing the pole with pike poles, digging the hole, and facing the pole, the butt of the pole is sawed 30 cm from the surface of

the ground until the saw is fully buried in the pole. The rails are then put in place and fastened to the pole with only the upper straps. The butt of the pole is sawed through and removed, and between the rails in the underground portion there is inserted a section of wood suitable for use as a filler block. The lower strap is put in place and tightened, then the hole is filled. Double wooden attachments are installed by a similar method, the only exception being that a wooden block is not inserted in the underground portion between the attachments. Installation of reinforced-concrete attachments is made in the same way as with rail attachments. In this case the diameter of the filler block must correspond exactly to the distance between the attachments in their underground portion and in tightening the straps the concrete must not be allowed to crumble. It is not permissible to strike the straps in order to close up the turns, for this may cause cracks or physical damage to the concrete, thereby lowering the strength and shortening the service life of the attachments. During the period of use of reinforced-concrete attachments it is necessary to check the condition of the concrete and, upon detecting cracks or exposed reinforcement, immediately to cover the areas with cement. The dimensions of rails, wooden attachments, and reinforced-concrete attachments according to the length of pole, as well as their fastening to the poles, are given in Chapter 12, Section III.

In repairing lines faded numbers on poles, attachments, and braces are to be restored.

## 22.4. Repair of Conductors

Included in the repair of conductors is the cutting-out of defective sections of conductor beneath ties on insulators, corroded sections of conductor (especially in the vicinity of chemical



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

plants, seacoasts, and railroad stations), removal of pieces of wire of incorrect diameter (that is, a 3-mm wire inserted in a 4-mm conductor and vice versa), elimination of excessive slack in conductors and of temporary joints made in eliminating faults, etc.

If repair work on conductors is not associated with a considerable number of conductor inserts, it is conducted as follows. The conductors from two or three poles in the vicinity of a proposed cut-out are freed and lowered with proper attention to safeguard against contact between conductors. This is done by drawing off the conductors with ropes slipped over the conductors by means of hooks of line wire. On each side of the proposed cut-out the conductor is held with draw grips and blocks. The rope of the blocks is tightened to the required positioning of the grips. Beyond the grips the conductor is cleaned and both these points are joined with sections of insulated wire. Then the conductor is cut between the grips and its unwanted section is replaced and the ends of the conductors are joined (steel conductors are joined by welding and copper and bimetallic conductors are joined by sleeving). The blocks are removed from the conductors and the conductor is carefully raised to the insulators so that it does not touch the other conductors. It is fastened to the insulators with tie wire.

In cutting out a twist the latter is removed in a 20-cm length. In its place there is inserted and welded with the conductors a previously prepared and carefully cleaned section of wire of the same diameter and material as the line conductor. The length of the prepared piece (the insert) in electric welding must be greater than the length of the cut-out by two diameters of the conductor to be welded, and in thermite welding it must be greater by 30 cm.

Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

In the installation of long inserts the new section of wire is unreeled along the ground at the site of replacement of the old wire (steel conductor is stretched). The old conductor is first unfastened, removed, and by means of straps of insulated wire or specially-made insulated suspension brackets it is fastened below a hook or crossarm. The new conductor is carefully raised, placed on the insulator grooves, and fastened -- care being taken that it does not touch live wires or other objects.

Then at one of the ends the conductor which is to be replaced is led through blocks and pulled to a certain sag between grips. Beyond the grips a temporary jumper of insulated wire is placed on the conductor. The conductor is cut between the grips and one end is joined with the wire prepared for the insert.

The same procedure is followed with the other end of the insert. In this step the first blocks are loosened and removed; the second blocks are drawn up to the required sag. Between the grips of the second blocks the ends of the insert are joined with the conductor and the blocks are also removed. The cut-out conductor is unfastened over its entire length and is dropped to the ground all at once so that it does not touch other conductors. The inserts are joined with the conductor no closer than 15-20 cm away from the insulator.

Small departures of conductor sag from the prescribed value are corrected by adjustment within several adjacent spans.

For this purpose the tie wires on several poles are loosened at the insulators, the conductor sag is equalized, and the tie wires are again fastened.

If adjustment must be performed over a considerable extent of line with the same defect throughout (for example, too much sag), then the sag is pulled in toward the center from both sides of the section and the blocks are used for the cut-out and final adjustment of the sag. If the sag is below normal, an appropriate insert is made in the center of the conductor. Decreasing of sag by zig-zag bends in the conductor, drawing the conductor up with a tie, or bending it around the neck of an insulator are all forbidden.

Conductor ties must be sturdy, otherwise ice, hoarfrost, temperature changes, and the tension within dissimilar spans will cause the conductors to move over the insulators in the direction of the larger span.

In the inspection of test poles it is necessary to give special attention to the condition of test clamps. The clamp contact must be cleaned and the ends of the conductors tinned. The grounding of lightning conductors must be checked. This may be done with the use of a portable a-c bridge, wherein the ground resistances must not be greater than 100 ohms.

## 22.5 Repair of Accessories

An insulator, hook, or pin which is to be replaced is freed from the conductor. The conductor is hung on an insulated suspension device (an egg insulator with two turns of tie wire) or on an insulated conductor at a hook or crossarm. The insulator and the hook or pin are removed and lowered to the ground on a rope. A new hook is screwed in place or a new pin installed on the crossarm, the cable filler is twisted on, and the insulator is fitted over it. The conductor is brought to the insulator and fastened with a new tie wire.

If an insulator is broken or a tie snapped on a corner pole and the insulator which is to be replaced is within the angle, then the conductor is held to the pole with a rope. With the installation of the new insulator the rope is removed, and the conductor is placed at the neck of the insulator and fastened with a tie. During this the supervisor must work from the outside of the angle.

Replacing of crossarms is done in the following manner. The ties on the crossarm are loosened so that the crossarm may be moved along the conductors. Ropes are then run from the ends of the crossarm to the crossarm above it and the bolts are removed. The crossarm is raised and the new crossarm is put in place and fully installed. The old crossarm is then shifted slightly along the conductors and lowered until the conductors are on a level with the new crossarm. The conductors are transferred and fastened with new ties. The old crossarm is lowered to the ground with a rope. The upper crossarm is replaced in the same way, but the old crossarm is held with rope to a cleat at the tip of the pole (Figure 22.5).

Cleaning of insulators. Cleaning of insulators is performed by the section supervisor. In individual cases the NDT assigns a worker to assist the supervisor on lines with a large number of conductors. The insulators over an entire section must be cleaned twice a year (in the spring and fall). On sections close to locomotive depots, metallurgical, cement, and chemical plants they must be cleaned each month. In areas with large population they must be cleaned four times a year. In localities with alkaline soil they must be cleaned every two months.

In order to increase the productivity of labor and to somewhat improve the quality of work in cleaning insulators an extremely practical device (Figure 22.6) proposed by M. M. Gorbachev is recommended. With this device the inner surfaces of the insulator can be cleaned. It consists of a steel rod 210 mm long with a pointed end for fastening of a wooden handle and a steel strip with an extension. The extension is bent at a right angle and serves for fastening of the strip at a hinge joint consisting of a rivet with a washer. The strip is shaped to conform to the inner surface of the insulators.

A piece of cloth is placed over the strip for cleaning the inside of insulators. The outside of the insulators is best cleaned with a rag.

In order to remove compacted dirt from the surface of the insulators it is necessary to use soap powder and clean water. After cleaning the insulator is wiped dry with a clean rag.

The insulator must not be cleaned with a solution of various acids, salts, and alkalis, nor with sand, pumice, or other materials which may damage the insulator glaze.

Cleaning begins with the top insulators, checking for cracks, chips, or worn places in the procelain (glaze) of the top groove due to rubbing of the conductor. Upon detection of these defects the insulator is replaced.

The other repair operations not listed in the present book (replacing poles in swampy ground, replacing compound poles, replacing poles installed on rail foundations, etc) are performed in accordance with the Pravila proyektiorvaniya, stroitel'stva i

remonta vozdushnykh linii svyazi [Regulations for Planning, Constructing, and Repairing Overhead Communications Lines] (Svyaz'izdat, 1952) under the direct supervision of the chief of the line section.

In performing repair work the supervisor must observe all safeguards against interruption of communications.

The supervisor must personally inspect the work performed on the section by the repair column. If defects still exist on the line, steps must be taken to eliminate them before the column leaves the section. The section supervisor assists the receiving commission in its work at the time of surrender of the repair report.

## 22.6. Repair of Cable Inserts

The following operations are performed in the maintenance of cable inserts: burying of exposed submarine and underground cable (on slopes, banks, and shores); reinforcing existing protective devices guarding the cable against physical damage; grading ground along the cable run by the use of fill dirt; straightening and in some cases replacing sleeves and covers which have been bent; eliminating defects in the lead sheathing; cleaning oxide from contacts and soldering poor contacts; bringing grounds up to technical standards; painting the cable cases of conduits, sections, and vaults; aligning and replacing surveying markers and painting and restoring numbers thereon.

Included in overhaul operations are: replacement of cables, line-matching units and protective devices, cable poles, and junction boxes in unsatisfactory condition; locating faults in cable sheath by application of air pressure and eliminating these faults by placing sleeves over them.

In cities with streetcars or electric railroads the currents returning from the motor car along the rails and ground to the power station sometimes enter the cable sheath at one point and leave it at another. The point where the current leaves the cable is known as the anodic zone. Disintegration (or, as it is also termed, corrosion) of the cable sheath occurs at this point. In order to protect the cable against this corrosion the anodic zones are located by measuring the potential on the cable sheath and taking the necessary steps to protect it by the use of bleeders, protectors, and feeder taps.

In the event of a fault in the cable (for example, reduced insulation in the conductors, indicating the penetration of moisture through the cable sheath) the fault is located by measurements and then the brigade is sent out for repair of the cable.

Such faults as burned fuses in cable cases, defective arresters and sockets, and poor contacts are immediately eliminated by the supervisor.

## 22.7. Safety Measures in Repairing Communications Lines

The repair of conductors of trunk circuits must, as a rule, be performed before 1400 hours Moscow time, that is, during the hours of smallest load on communications lines. In damp weather work on copper conductors with carrier transmission is not permitted. Special care must be exercised in working after rain in order to avoid disruption of normal communications operation due to contact of conductors with wet clothing and with wet ropes from blocks. Copper conductors carrying voice-frequency carrier telegraph transmission must not be held with bare hands. Rubber gloves are to be worn during such work.

The best method of avoiding interference with communications is to place spiral rubber sleeves 60-70 cm long over the copper conductors at the pole on which the work is being conducted.

The loops of repair belts should, as a rule, be covered with canvas or some other insulating material. Conductors must not be placed directly on the hooks or crossarms. Cable filler or rope must not be used to suspend conductors in replacing insulators. Pliers longer than 200 mm must not be used in working on poles with crossarm suspension, since the existing distance of 20 cm between conductors is such as will cause possible shorting of conductors across pliers of greater length.

In order to protect conductors against knicks and abrasion during installation and removal of ties it is recommended that a special device (Figure 14.12) in the form of a wooden shoe be used.

While the repair column is at work on his section the line inspector must be sure that the workers observe all safety precautions in working with live conductors.

## 22.8. Safety Techniques

In operations for the repair and maintenance of line installations strict attention must be paid to the Pravil po tekhnike bezopasnosti pri rabotakh na vozdushnykh liniyakh svyazi [Safety Rules for Operations on Overhead Communications Lines].

For this purpose it is necessary that all line supervisors and workers be thoroughly familiar with the procedures for using tools (climbers, belts with snap hooks, blocks, etc) and the methods of performing hazardous operations, keeping in mind that the smallest breach of these rules can result in shock and accidents.

Each day before the beginning of work the tools are carefully checked and safety devices are inspected. Defective tools and devices are immediately removed. The person performing the inspection enters the results in a special notebook. In giving out work assignments the leader of operations (the section leader, the brigade leader) must tell the workers what they must do in order to observe the safety regulations.

In the performance of the more hazardous line operations (replacing corner poles, working at crossings with high-voltage lines and the contact conductors of streetcar lines and electrified railroads, at river crossings, crossings at highways and railroads, in populated localities, in the hauling, loading, and unloading of poles, etc) the leader of the line section must be present in person to see that the workers observe the safety regulations.

Work is not permitted on lines during the approach of a storm and much less during the storm. Line work is also forbidden during winds with intensity above eight balls and when air temperature is above or below the limits prescribed by the local authorities -- with the exception of work performed during emergencies. In eliminating faults in an emergency the line a supervisor goes out on the line with the workers.

In the event of an accident the victim is given first aid as soon as possible and dispatched to the nearest medical station. The workers must be informed of the location of the medical station before beginning work.

Each accident in the course of work must be carefully investigated within 24 hours of its occurrence and a report prepared. Immediate steps must be taken to prevent recurrence of such an accident.

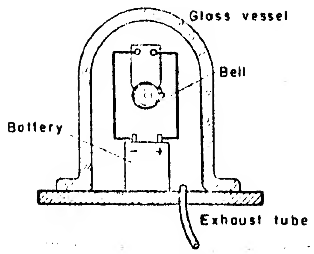



Figure 8.1 With the air evacuated from under the hood the bell is not heard.

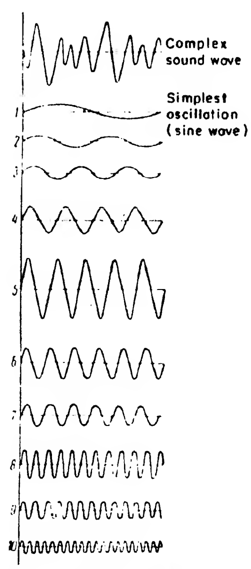



Figure 8.2. A complex sound consists of a large number of sine waves (harmonics).

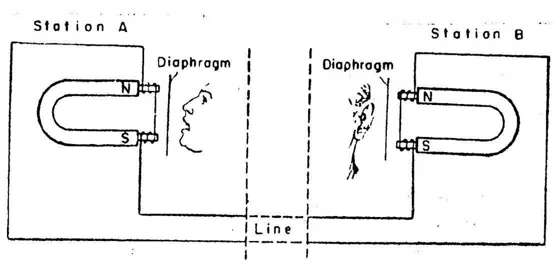



Figure 8.3. The simplest telephone system.

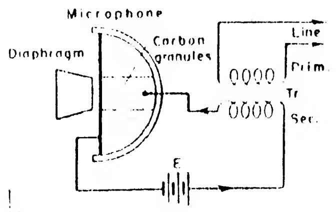



Figure 8.4. Transmitter circuit.

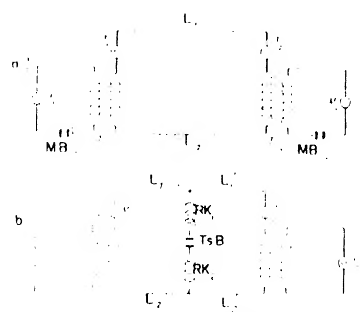



Figure 8.5. Telephone communications layout: a, the MB system; b, the TsB system.

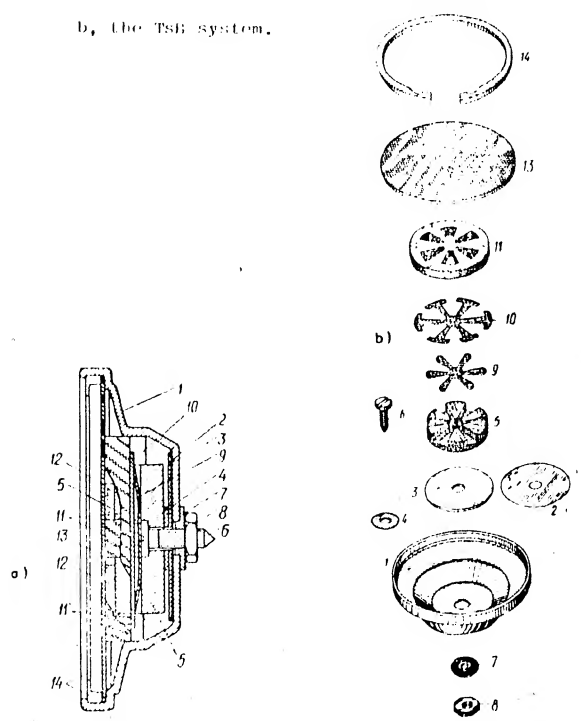


Figure 8.6. No 5 transmitter capsule: a, in assembled form; b, components.

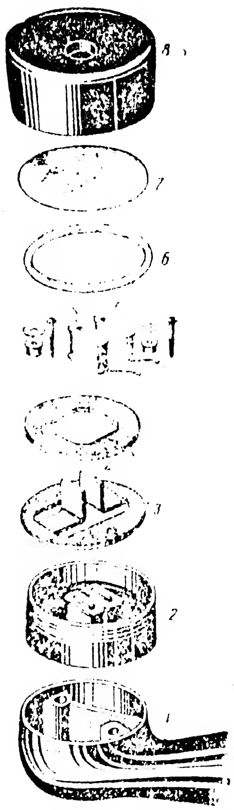



Figure 8.7. Construction of telephone receiver and components.

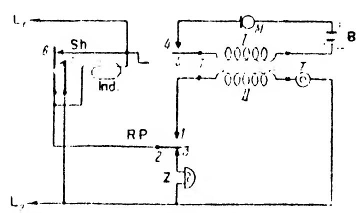



Figure 8.8. Basic diagram of MB telephone.

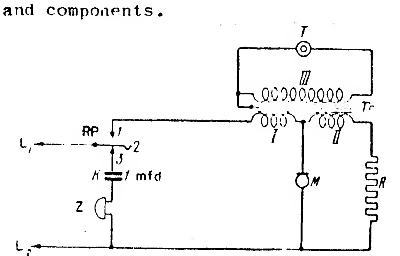



Figure 8.9. Basic diagram of TsB telephone.

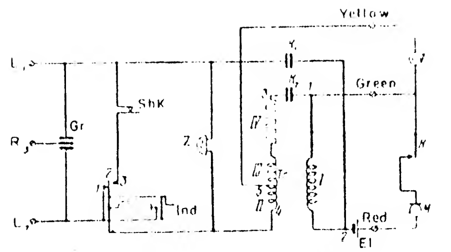



Figure 8.10. Basic diagram of UNAI-42 telephone.

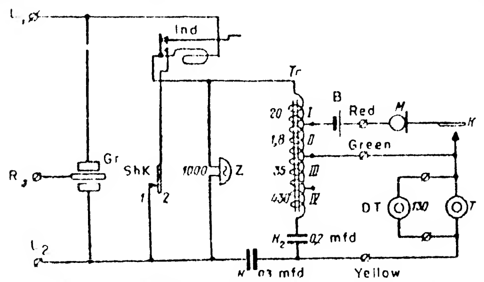



Figure 8.11. Basic diagram of TAI-43 telephone.

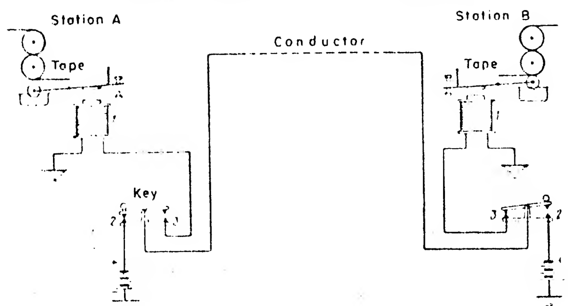
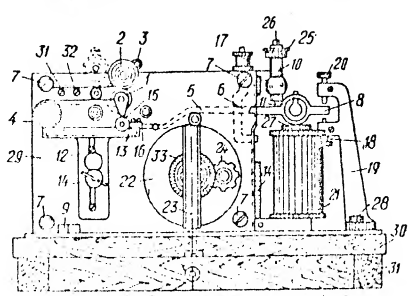



Figure 9.1. Arrangement for simplest telegraph communication.



[illegible] .2. [illegible] apparatus.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

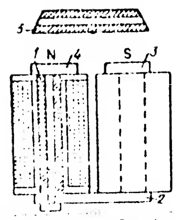



Figure 9.3. Electromagnet.

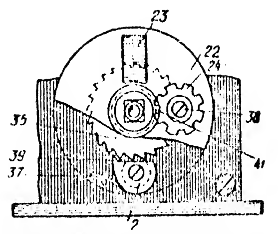
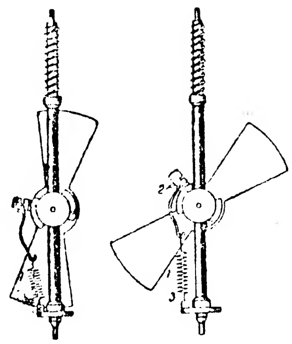


Figure 9.4. Winding drum.



a) b)

Figure 9.5. Governor.

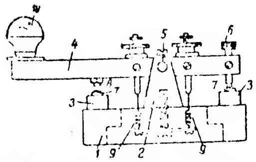


Figure 9.6. Key (transmitter.

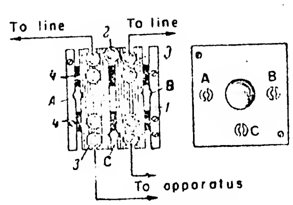



Figure 9.7. Laminated discharger-switch.

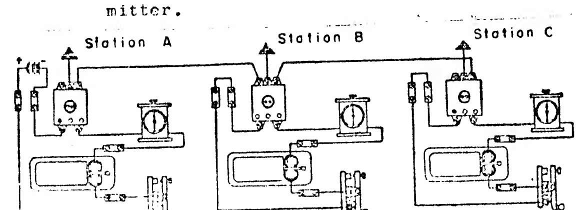



Figure 9.8. Scheme for continuous-current connection of 3 stations.

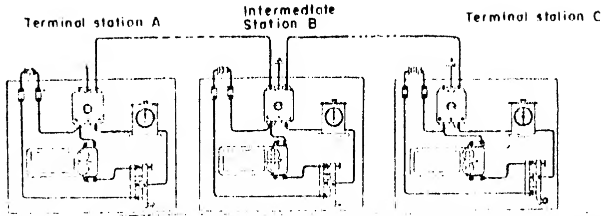



Figure 9.9. Scheme for operating-current connection of 3 Morse stations.

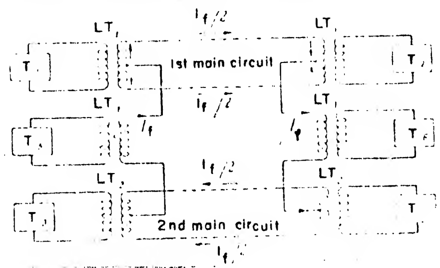



Figure 10.1. Organization of a phantom circuit.

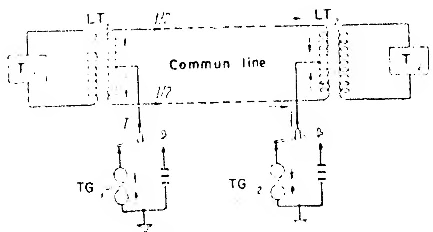



Figure 10.2. Scheme for simultaneous telephone and telegraph operation.

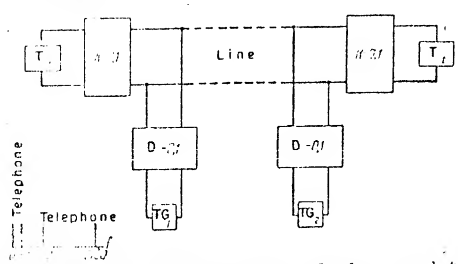



Figure 10.3. Scheme for simultaneous telephone and telegraph operation using filters.

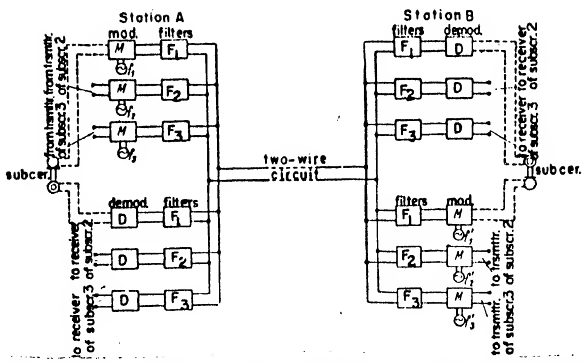



Figure 10.4. Scheme of high-frequency current telephony.

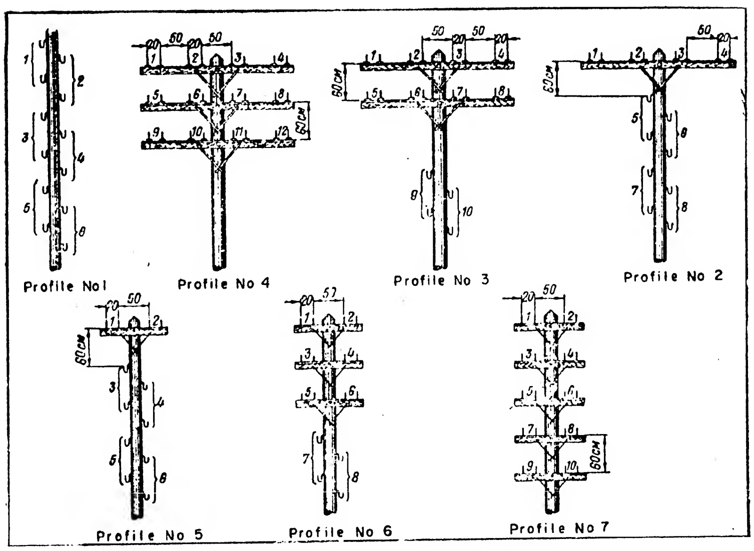



Figure 12.1. Typical line profiles.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

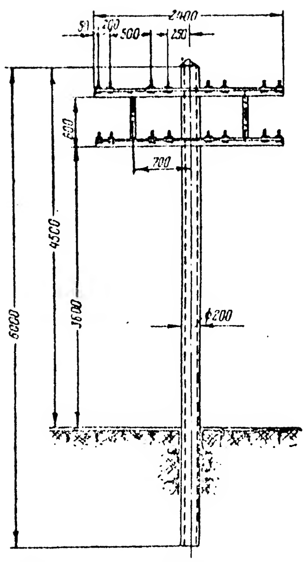



Figure 12.2. Intermediate reinforced-concrete pole (clearance 3 m) for lines of types O and N.

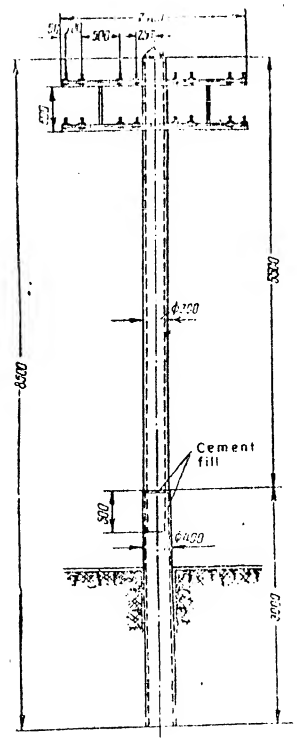



Figure 12.3. Intermediate reinforced-concrete pole (clearance 4.5 m) for lines of types U and OU.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

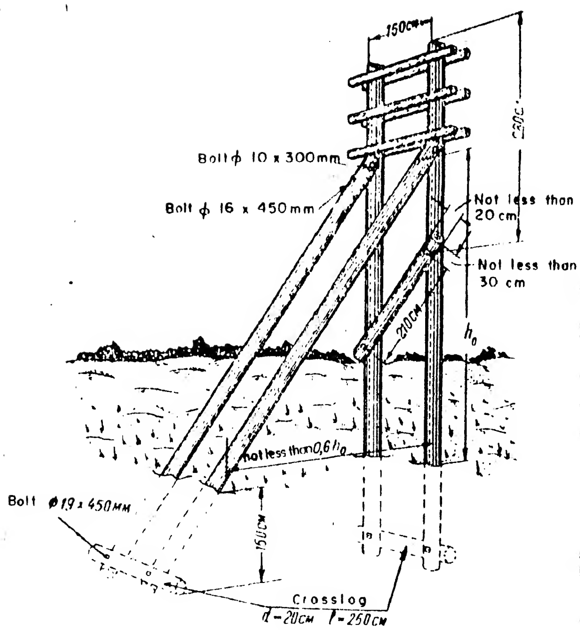



Figure 12.4. Semi-anchor pole.

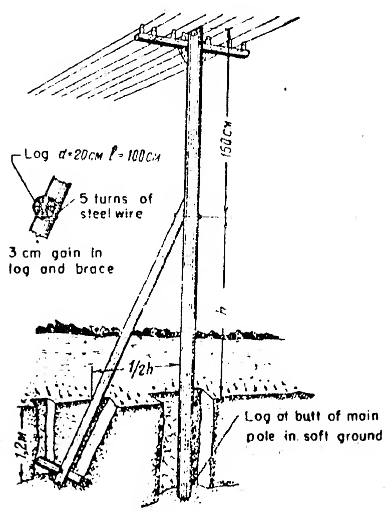



Figure 12.5. Anti-wind pole.

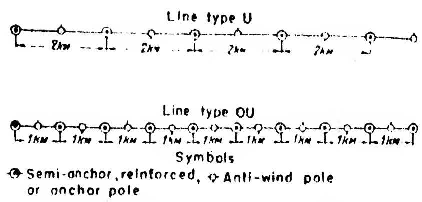



Figure 12.6. Arrangement of anti-wind, semi-anchor, and reinforced poles.

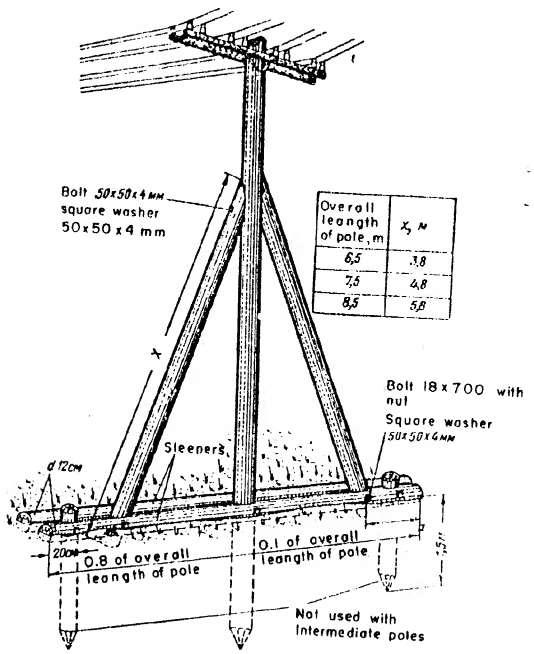



Figure 12.7. Corner pole for swampy ground.

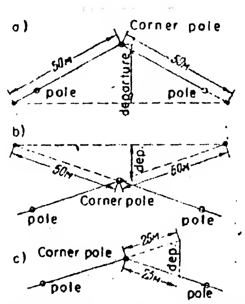



Figure 12.8. Determining the normal departure of angle.

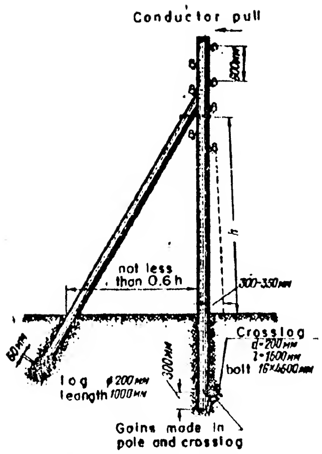



Figure 12.9. Corner pole reinforced with brace.

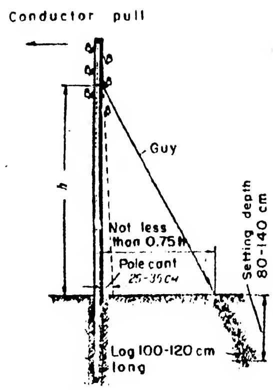



Figure 12.10. Corner pole reinforced with guy.

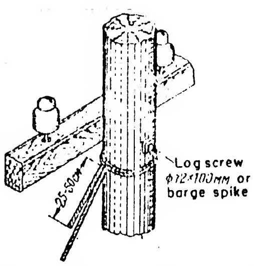



Figure 12.11. Fastening guy to pole.

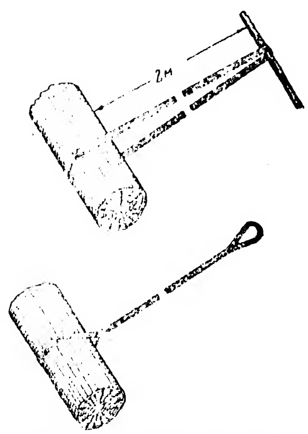



Figure 12.12. Fastening wire strap to anchor log.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

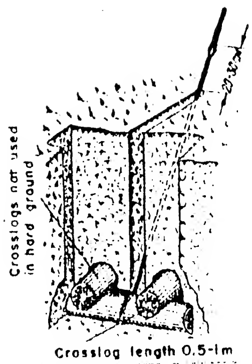



Figure 12.13. Fastening anchor in soft ground.

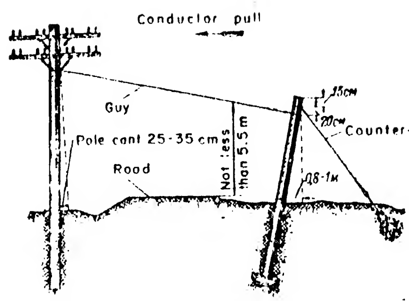



Figure 12.14. Installation of guy pole.

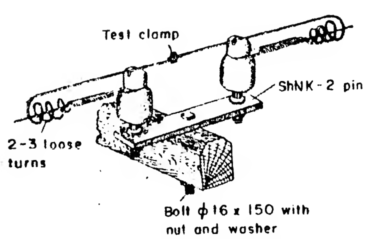



Figure 12.15. Fastening conductors to test strap.

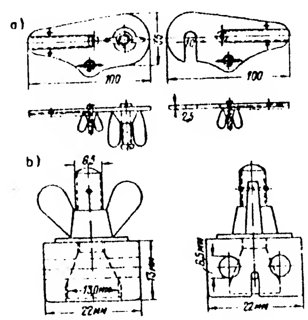



Figure 12.16. Test clamp: a, old type; b, new type.

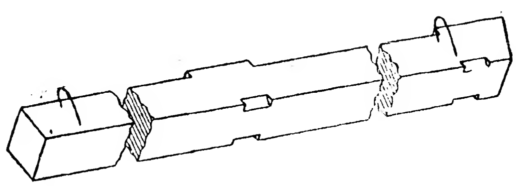


Figure 12.17. Reinforced-concrete attachment of type PR.

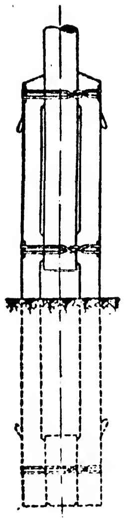


Figure 12.18. Paired reinforced-concrete attachment of type SPR.

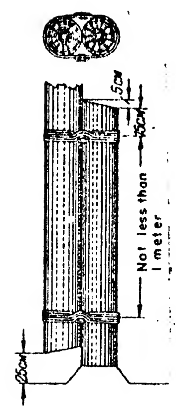



Figure 12.19. Fastening pole to wooden attachment.

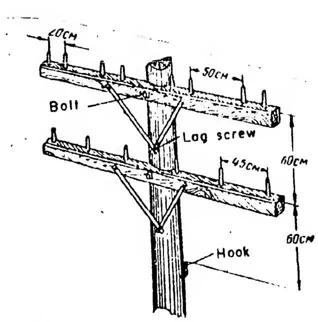



Figure 13.1. Mounting wooden crossarms and pins on intermediate poles.

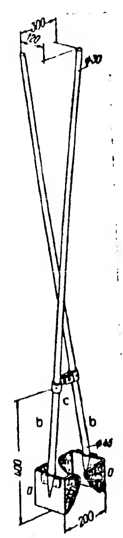



Figure 14.1. Hole digger.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

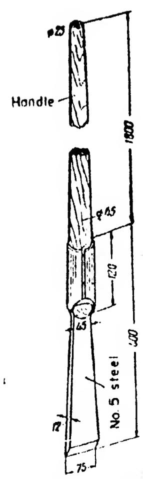



Figure 14.2. Chopping blade.

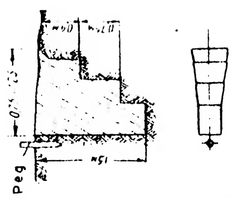



Figure 14.3. Shape of hole for pole.

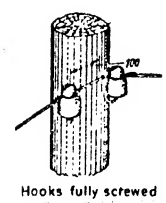



Figure 14.4. Twin hooks on corner pole.

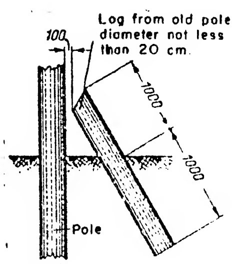



Figure 14.5. Guard stub.

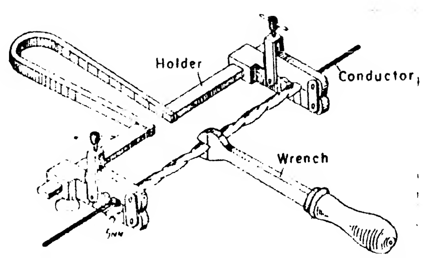



Figure 14.6. Sleeve joining of conductors.

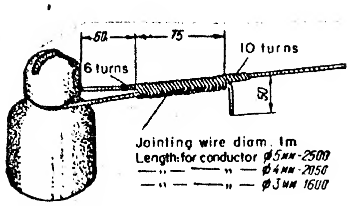



Figure 14.7. Dead-end tie for steel conductors.

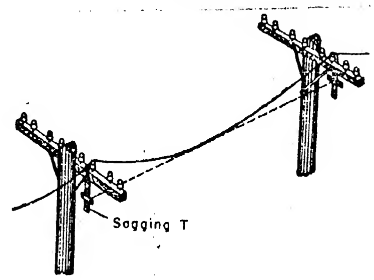



Figure 14.8. Determining conductor sag.

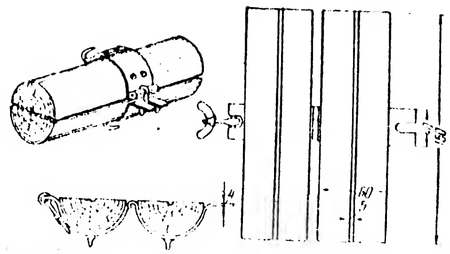


Figure 14.9. Grip for pulling steel-reinforced aluminum conductors.

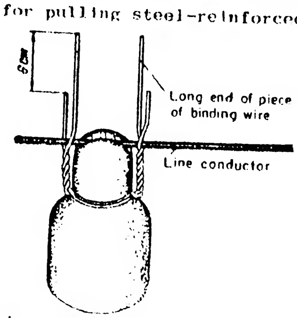



Figure 14.10. Fastening conductor to insulator on a straight-run pole.

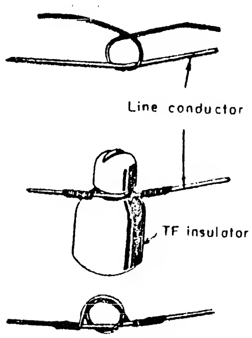



Figure 14.11. Fastening conductor to insulator on a corner pole.

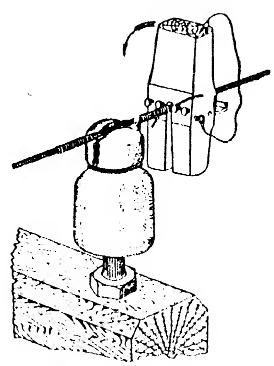


Figure 14.12. Fastening a conductor by means of A. V. Ivanov's device.

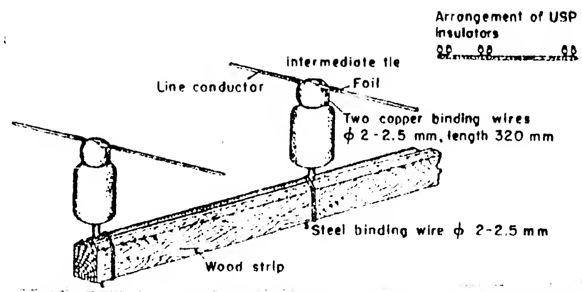



Figure 14.13. Fastening conductor-whip eliminating (USP) insulators.

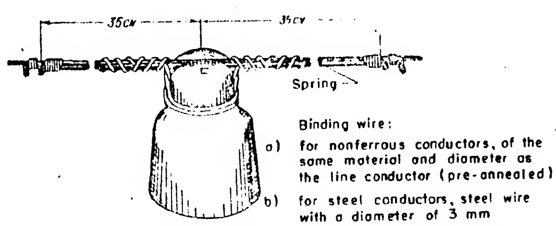



Figure 14.14. Spring armoring of a conductor at a straight-run insulator.

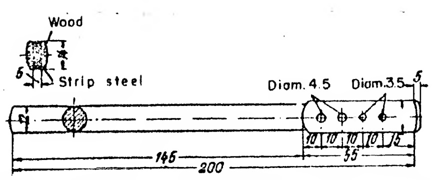



Figure 14.15. Wrench for spring armoring of conductors.

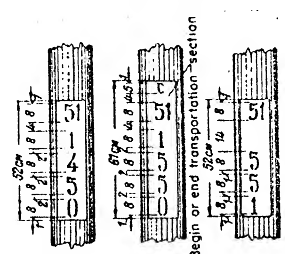



Figure 14.16. Pole numbering.

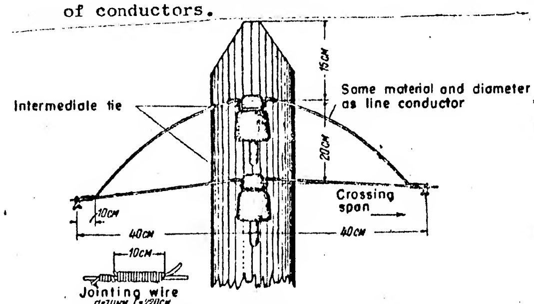



Figure 14.17. Fastening conductors by the double-hang method.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

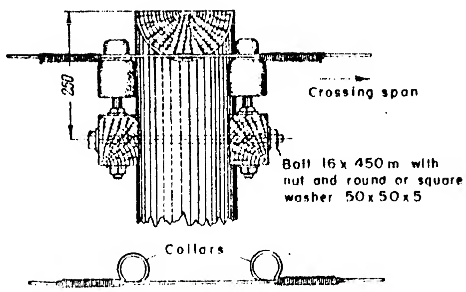



Figure 14.18. Double fastening of conductors on crossarms.

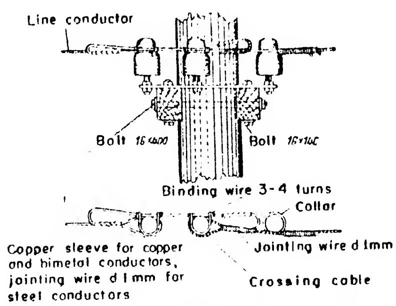



Figure 14.19. Joining cable with single conductor.

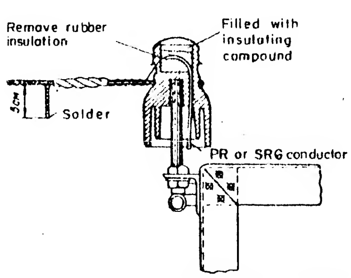



Figure 14.20. Entrance insulator and rigging.

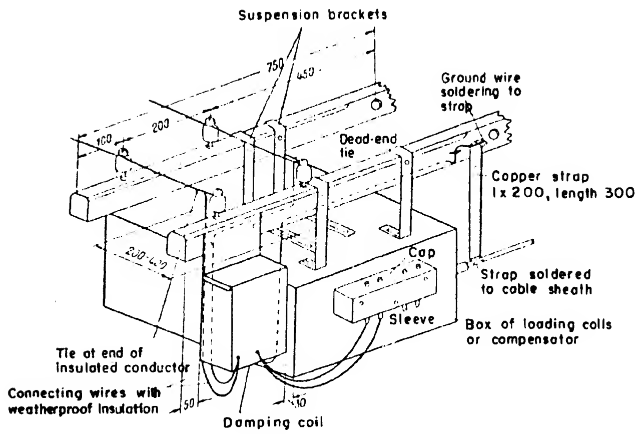



Figure 14.21. Placement of compensator (or loading-coil assembly) on cable pole.

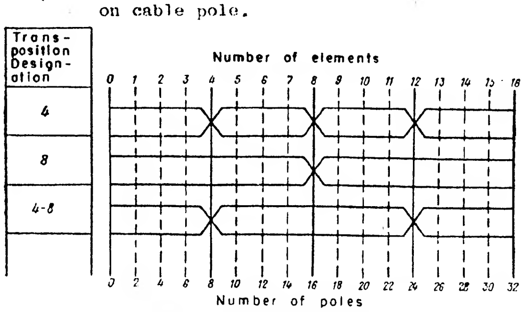



Figure 15.1. Transposition arrangement of circuit conductors.

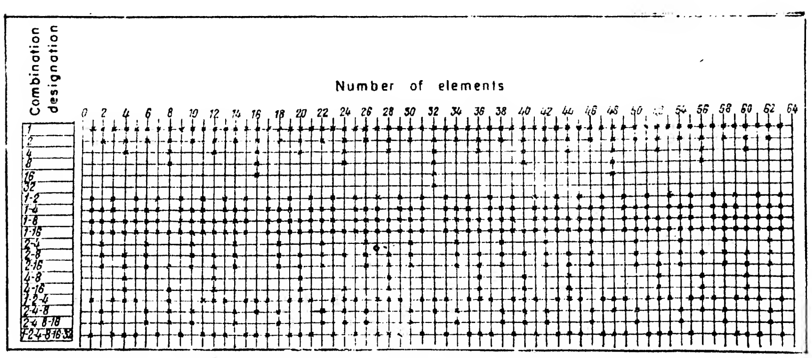



Figure 15.2. Forming different combinations of circuit transpositions.

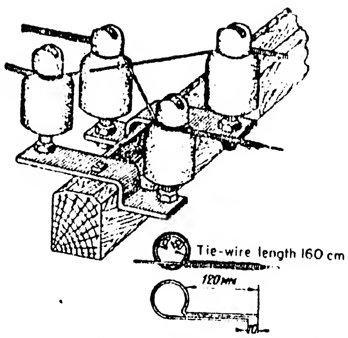



Figure 15.3. Transposition of conductors on brackets.

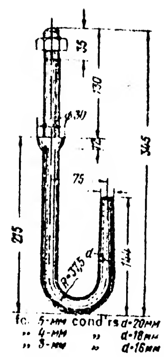



Figure 15.4. Stringing hook for transposition of circuit conductors.

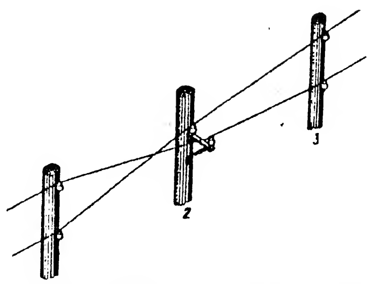



Figure 15.5. Transposition of circuit conductors on L-brackets.

Figure 16.1. A twisted pair.

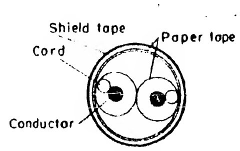



Figure 16.2. Shielded pair

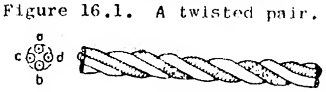



Figure 16.3. Star-twisted quad.

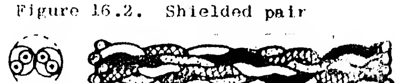


Figure 16.4. Two-pair-twisted quad.

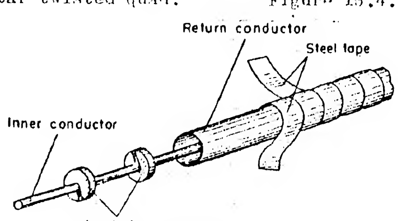



Figure 16.5. Coaxial pair.

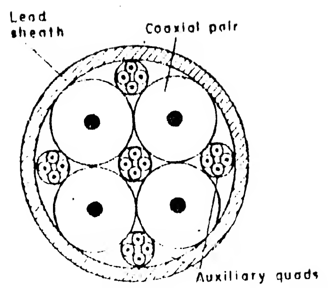



Figure 16.6. Cable with 4 coaxial pairs.

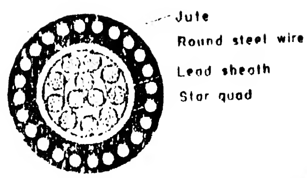



Figure 16.7. TZK cable with 12 quads.

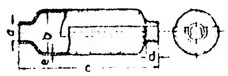


Figure 17.1. Lead coupling sleeve.

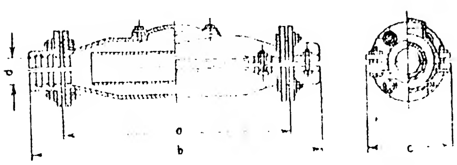


Figure 17.2. Cast iron jacket for lead coupling sleeves.

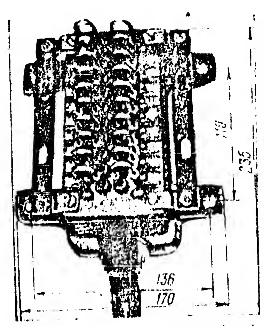



Figure 17.3. Ten-pair box.

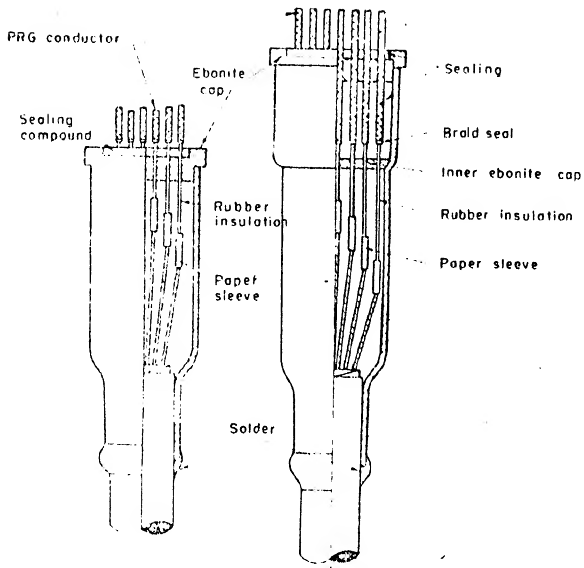



Figure 17.4. Cable shoes.

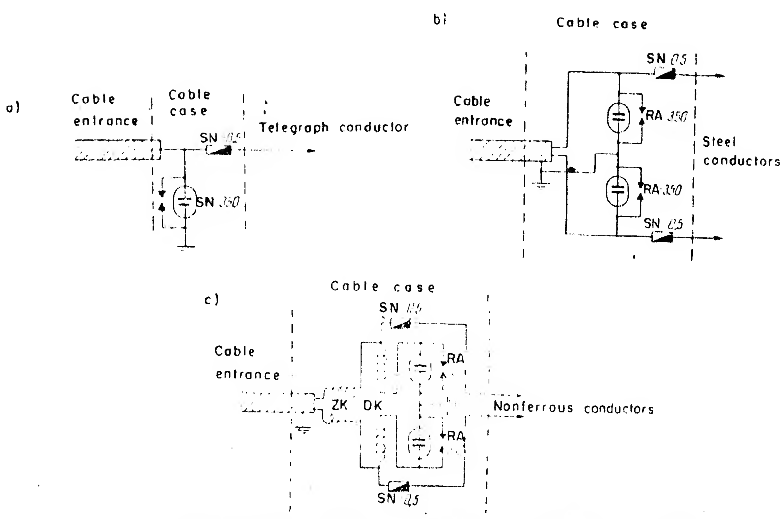



Figure 17.5. Arrangement for lightning protection.

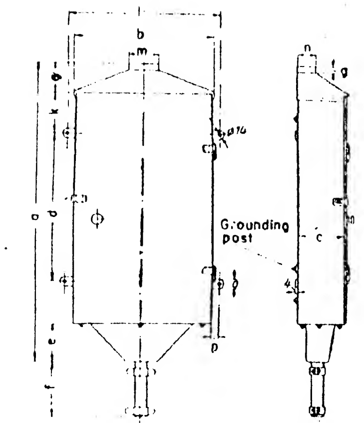



Figure 17.6. Sketch of cable case.

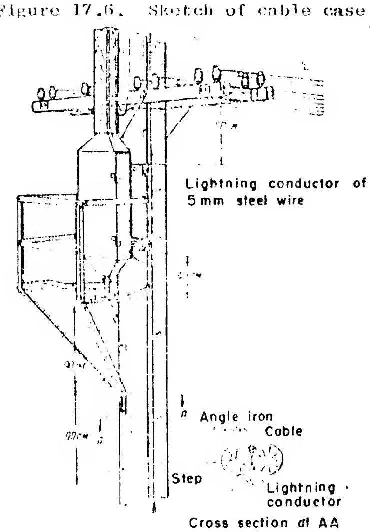



Figure 17.7. Cable pole.

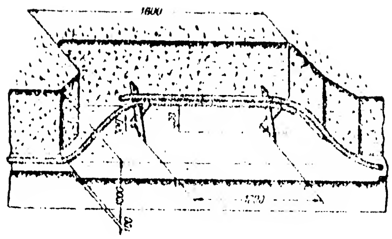



Figure 18.1. Placing the cable on frame horses.

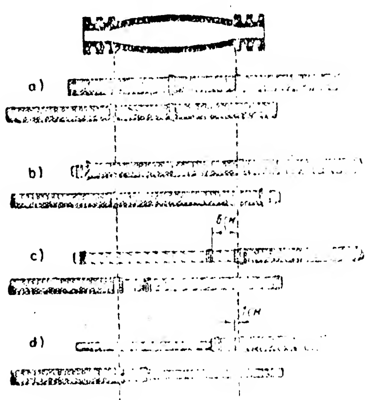



Figure 18.2. Stripping cable ends for installation of sleeves.

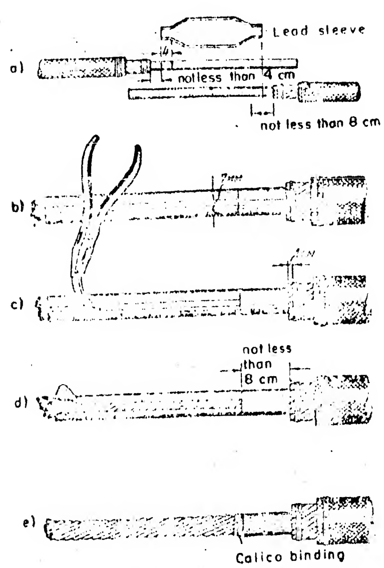



Figure 18.3. Removing the lead sheath from the cable end.

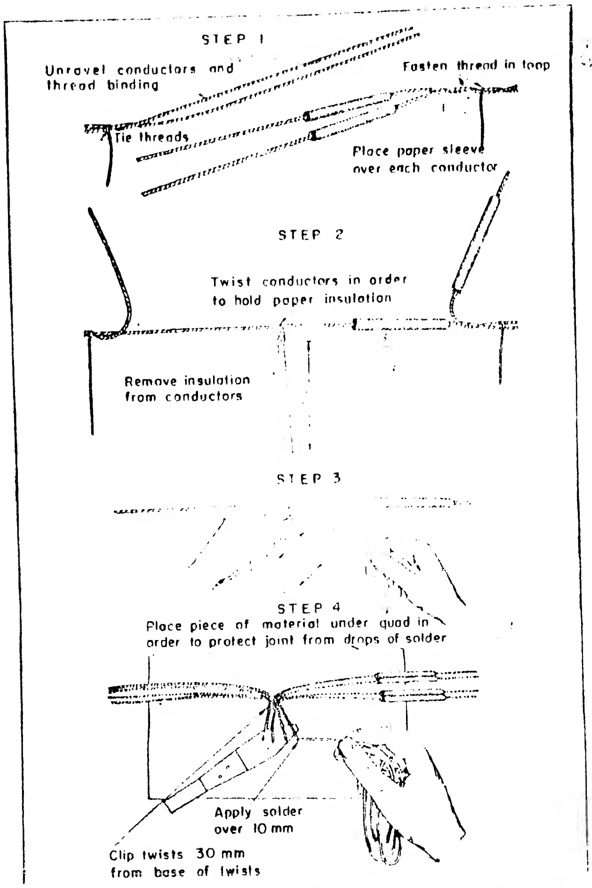



Figure 18.4. Twist-joining of copper conductors.

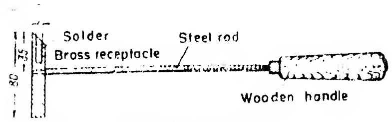



Figure 18.5. Soldering instrument with recess for solder.

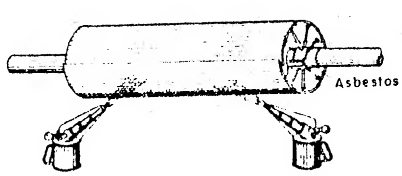



Figure 18.6. Arrangement for drying-joined pairs and quads.

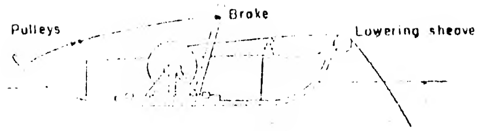



Figure 19.1. Barge equipment for laying submarine cable.


Figure 19.2. Scheme for laying submarine cable with the use of barrels.

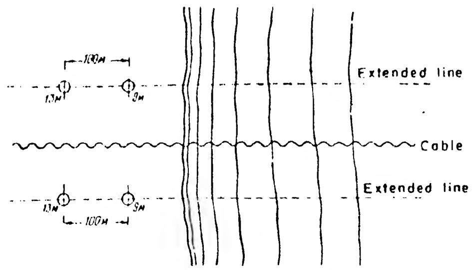



Figure 19.3. Signal arrangement of submarine cable crossing.

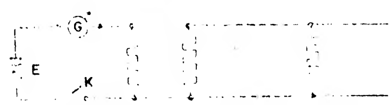



Figure 20.1. Open-ended line.

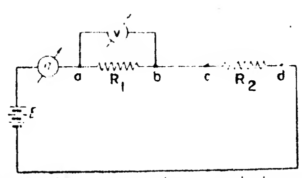



Figure 20.2. Circuit for measuring resistance with a voltmeter and an ammeter.

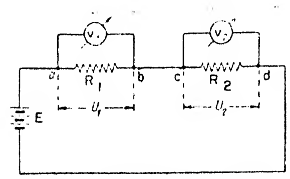



Figure 20.3. Circuit for measuring resistance with a voltmeter.

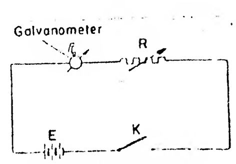



Figure 20.4. Circuit for measuring resistance with an ohmmeter.

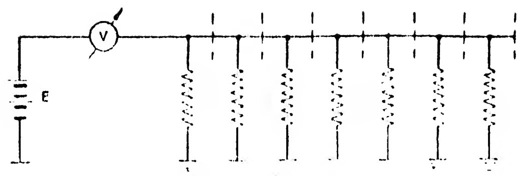



Figure 20.5. Circuit for measuring insulation resistance of a conductor with a voltmeter.

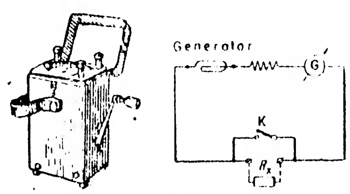



Figure 20.6. Circuit for measuring insulation resistance with a megohmmeter.

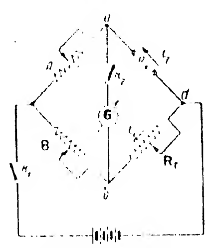



Figure 20.7. Circuit for measuring resistance with a bridge.

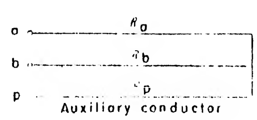



Figure 20.8. Circuit for measuring asymmetry of conductors by the 3-sum method.

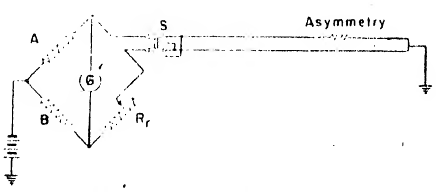



Figure 20.9. Circuit for measuring asymmetry of conductors by the grounded-loop method.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

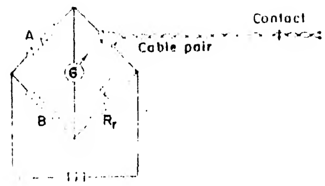



Figure 20.10. Measuring arrangement for locating a short.

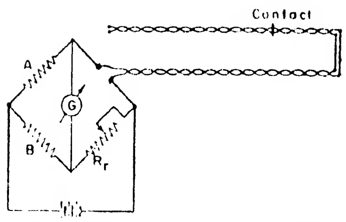



Figure 20.11. Measuring arrangement for locating the point of contact of conductors with the use of a non-faulted pair.

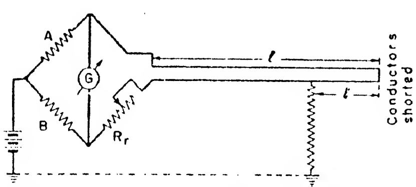



Figure 20.12. Measuring arrangement for locating an insulation fault by means of a bridge with a fixed arm ratio.

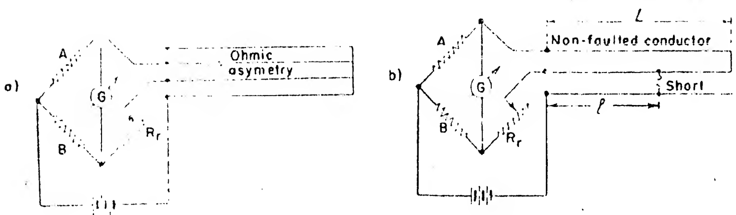



Figure 20.13. Determining ohmic asymmetry by means of a bridge with a fixed ratio for the 2 arms.

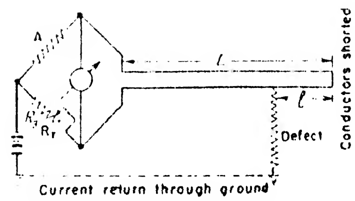



Figure 20.14. Locating an insulation fault by means of a bridge with a variable arm ratio.

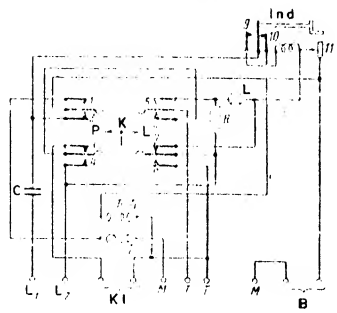



Figure 20.15. Basic diagram of fault locator (IP-47).

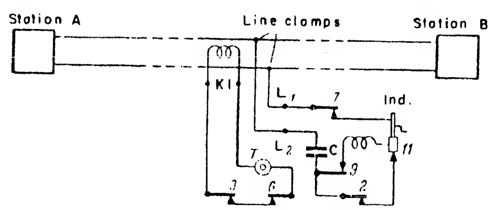



Figure 20.16. Diagram of IP connection in locating contact between conductors.

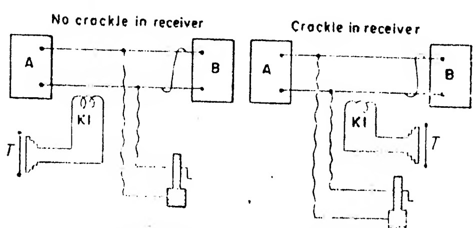



Figure 20.17. Diagram of IP connection with short in circuit.

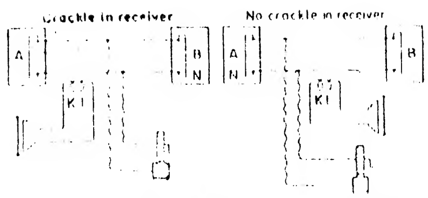



Figure 20.18. Diagram of IP connection with break in conductor.

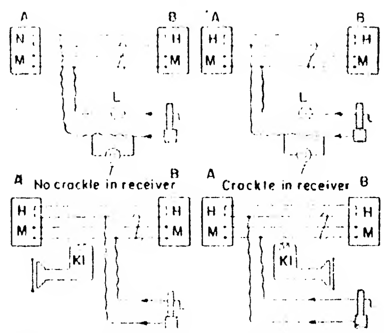



Figure 20.19. Diagram of IP connection with contact between conductors of 2 telephone circuits: a, determining contacting circuits by means of signal lamp or receiver; b, determining direction of fault by means of search coil.

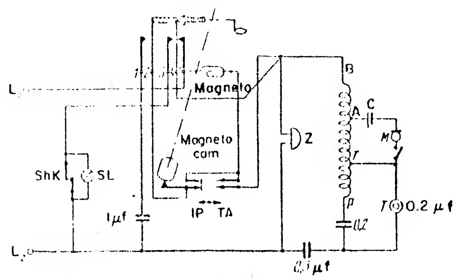



Figure 20.20. Basic diagram of IP-50 fault locator.

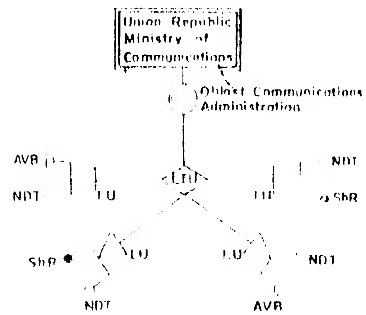



Figure 21.1. Organizational scheme of line service.

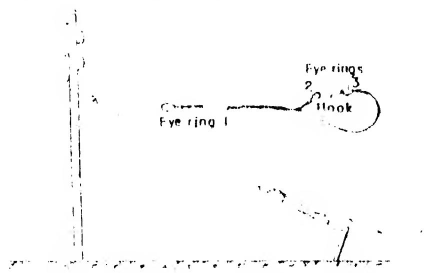



Figure 22.1. Straightening a pole with a temporary guy.

Figure 22.2. [illegible] the pole. [photo]

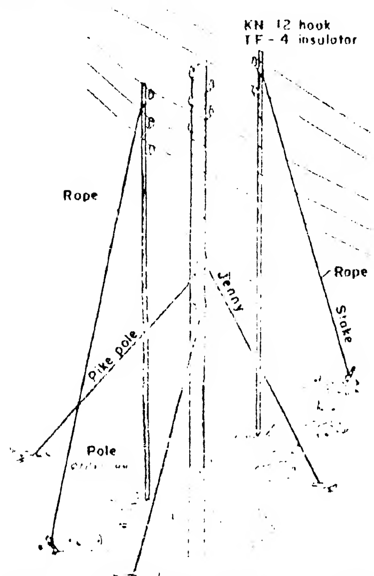



Figure 22.3. [illegible] of a pole.



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

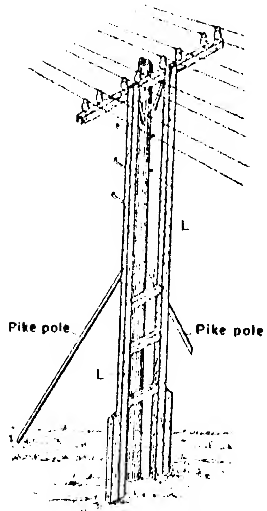



Figure 22.4. Replacing an intermediate pole with the use of a ladder.

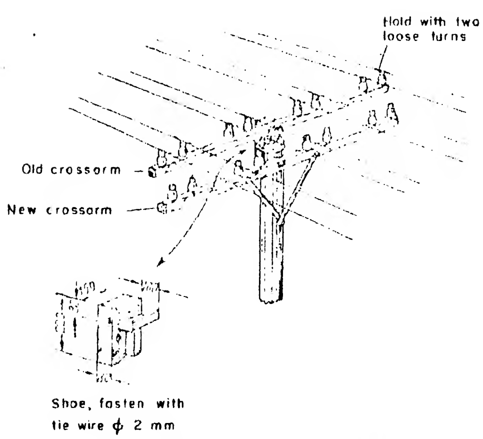



Figure 22.5. Replacing crossarms.

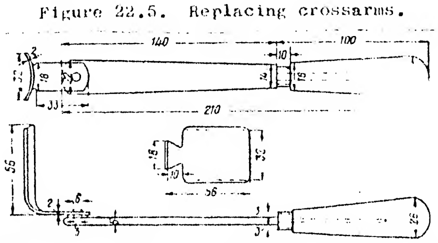



Figure 22.6. Device for cleaning insulators (after M. M. Gorbachov).



Sanitized Copy Approved for Release 2010/04/19 : CIA-RDP81-01043R000200230012-7

25X1

Page Denied